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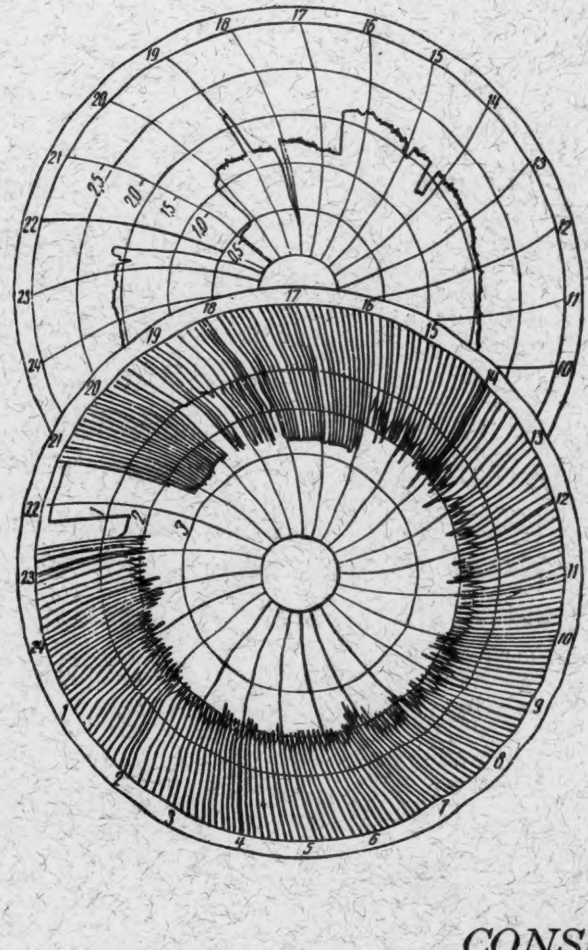

МЕТАЛЛУРГ

metallurg

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FOR FURTHER DEVELOPMENT OF THE FERROUS INDUSTRY

In 1957 the Soviet ferrous industry achieved a further increase in production: output of pig iron constituted 37 millon t, steel – 51 million t, steel tubing – 4.2 million t, coke – 48.6 million t, iron ore – 84.2 million t. Compared with the output level in 1956 the output of pig iron increased by 4%, steel – by 5%, rolled product – by 6%, steel tubing – by 9%, coke – by 4% and iron ore – by 8%.

The production growth was promoted by the radical reorganization of industrial management, which was carried out last year and which brought about the exposure and utilization of new potentialities, and by continued improvements of technology and adoption of new techniques.

In spite of the output increase achieved last year, there were substantial shortcomings in the ferrous industry. Thus, although the over-all target of rolled product output was attained, the separate output targets of some types of rolled products were not fulfilled; output of iron ore, pig iron and steel fell somewhat short of the planned figures.

The annual plan with respect to metallurgical production was fulfilled by the Sovnarkhozes (Councils of National Economy) of Moscow and the Moscow region, Leningrad, Vologda and other regions. Industrial establishments of these regions attained considerable successes. However, several industrial establishments of the Sovnarkhozes with a developed ferrous industry failed to fulfil the annual state plan (Cheliabinsk, Sverdlovsk, Stalino, Dnepropetrovsk).

The failure of some works to fulfil the state plan can be explained to a great extent by an inadequate utilization of productive capacities caused by a slackening in the technological discipline, lack of the necessary maintenance of equipment and an unsatisfactory organization of its repairs. At several works there were delays in the supplies of basic materials.

In the ferrous industry as a whole, in spite of the increase in pig iron output, the utilization coefficient of blast furnace volume somewhat deteriorated in connection with the introduction of lean ores into the charge, and was 0.79 compared with 0.78 in 1956.

Steel output per one square meter of the hearth area of open-hearth furnaces increased by 3% compared with 1956, and hence it was possible to increase the total steel output from the existing equipment by more than 1 million t.

1957 was characterized by a further rise in the technical level of the ferrous industry. In the blast-furnace industry the fluxed agglomerate was much more extensively applied; in the steelmaking industry the manufacture of open-hearth and converter steel with the use of oxygen was increased; the adoption of the treatment of steel under vacuum, improving its physical and mechanical properties, was continued on an industrial scale; the production of new grade steel and alloys was mastered.

At the same time, the introduction of an effective method of continuous casting of steel at the metallurgical works was not carried out satisfactorily. The plan of the complex automation of metallurgical processes was not fulfilled.

In the steel-rolling industry, the equipment of new modern rolling mills was carried out: wire-drawing and light-section mills at the Krivoi Rog Works, a reversible strip mill with furnace coilers at the Novo-Lipetsk Works, a cold-rolling sheet mill at the Magnitogorsk Combine and others.

Productivity in the ferrous industry increased by 5% compared with 1956 (the working day being shortened in the second half of 1957).

In 1957, new blast furnaces were put into operation at the Stalino, the Alchevsk and the Makeevka Works and furnace No. 1 at the Il'ich Works was modernized, its capacity being increased; a large wire-drawing mill and two converters at the Krivoi Rog Metallurgical Works, a rolling mill at the Novo-Lipetsk Works, a tube billet mill, and blooming mill at the Baku Tube Works, open-hearth furnaces at the "Azovstal," "Zaporozhstal," Alchevsk, and Zakavkaz Works and at the Nizhne-Tagil Metallurgical Combine were put into operation. A new coke and by-product works in the Ukraine and the Sokolovskii mine in Kazakhstan were put into operation. The mining of ore commenced at the Abakansk iron mine in Siberia.

All this is certainly a large contribution to a further development of the ferrous industry, but the constructors did not manage to reach the target with regard to major constructions in 1957. Not all the capacities envisaged in the plan in the steelmaking and rolling industries were put into operation. Especially unsatisfactory is the introduction of new capacities in iron-ore mining. In all, the plan of major constructions in the ferrous industry was only 90% completed.

The 1958 plan envisages a further increase in production and carrying out of substantial measures for a speedy development of the ferrous industry. The targets for this year are: pig iron – 39.1 million t, steel – 53.6 million t, rolled product – 41.7 million t, iron ore – 87.0 million t and coke – 50.6 million t.

The growth of production is envisaged mainly on account of a further improvement in the operation of existing equipment. Many works in the ferrous industry, first of all the Magnitogorsk and the Kuznetsk Combines achieved very high technical indices in the operation of main units, exceeding the best indices of similar works of capitalist countries, including U.S.A. And yet we have works which operate below their capacities. Thus, for instance, the idling periods of open-hearth furnaces at the Cheliabinsk Works are twice as long as those at the KMC and the MMC. There are also considerable idle periods at the Nizhne-Tagil Metallurgical Combine.

Special attention is paid in the plan for 1958 to the increase of the capacities of the ferrous industry: capital investment is fixed at 12.1 billion rubles, i.e., by 3.5 billion more than was invested in 1957. The capital investment for the construction of metallurgical works increases by 40% and for ore mining by 73%. Taking into account the great importance for national economy of the iron ore deposits in the region of the Kursk magnetic anomaly, 400 million rubles or 3.5 times the amount spent in 1957 is earmarked for the development of mines in that region. The construction of the Sokolovsko-Sarbaiskii Ore Beneficiation Combine in the Kazakh SSR will be continued at a forced pace.

In accordance with the directives of the XXth Congress of the CPSU (Communist Party of the Soviet Union), in the 1958 plan enormous importance is attached to a further development of the eastern regions of our country. Capital investments at the existing establishments – the Magnitogorsk, the Kuznetsk and the Nizhne-Tagil Combines and the Cheliabinsk Metallurgical Works are substantially increased. This year the construction of the West-Siberia Metallurgical works – most important link in the third metallurgical center in the East – and the Korshunovskii Ore Beneficiation Combine in the Irkutsk province will be started.

In 1958, seven blast furnaces, two of them in the RSFSR (Russian Socialist Federated Soviet Republic) and five in the Ukraine, four open-hearth furnaces (three in the RSFSR and one in the Ukraine), two converters (in the Ukraine), 14 electric furnaces (13 in the RSFSR and one in the Ukraine); eight rolling mills (four in the RSFSR and four in the Ukraine) should be put into operation. Moreover, in 1958, there should be sufficient ground-work to ensure the commencement of the operation of another seven large blast furnaces and several other metallurgical units in the next year.

The Cheliabinsk, Sverdlovsk, Orenburg, Vologda, Lipetsk, Kemerovo, Belgorod, Kursk and other Sovnarkhozes where the construction of works for ferrous metallurgy and related branches is particularly sizable should concentrate material and human resources on these objects, strengthen operating organizations and introduce new ones, enlarge their operating bases and ensure the priority supplies of material, equipment, and transportation for the most important constructions.

Extremely important tasks are put before the workers of the ferrous industry. From the very beginning of the year, the leaders of Sovnarkhozes, works and plants should mobilize forces for making use, in every way possible, of local potentialities for a marked improvement of all the indices of works operation and for a definite fulfilment – and more – of the 1958 annual plan.

BLAST-FURNACE PRODUCTION

DESULFURIZATION OF PIG IRON OUTSIDE THE BLAST FURNACE

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Institute of Metallurgy of the Acad. Sci. USSR and the Novo-Lipetsk Metallurgical Works

The present-day methods of pig iron manufacture make possible the production of metal with a low sulfur content. However, the removal of sulfur from the pig iron in the course of smelting entails an increased consumption of raw materials and causes a lowering in the operating efficiency of the equipment. Hence, it is much more convenient to carry out the desulfurization of pig iron outside the blast furnace. The introduction of this method will allow a considerable improvement in the technical and economic indices of production.

The effectiveness of the desulfurization process depends not so much on the desulfurizing power of the reagent as on the method of its introduction into the pig iron, Desulfurization methods tested at home and abroad are shown in Fig. 1.

None of these methods is in wide commercial use because of the costliness of the reagents employed, a low degree of desulfurization, a high consumption of the reagents, and the low output of the equipment. Furthermore, a common disadvantage of these methods is an inadequate mixing of the metal with the reagent and a limited time of contact between them. Because the reactive surface area is not well developed, only part of the desulfurizing agent and not all of it takes part in the process. Hence, the degree of desulfurization is low.

Desulfurization methods employing electromagnetic mixing, vacuum, and electrolysis are of interest but have been inadequately studied.

Successful experiments in treating pig iron with lime in a 2.5 t ladle, carried out by the IRSID Institute (France), have aroused great interest. It is, however, doubtful whether satisfactory results could be obtained on treating pig iron in an 80-100 t ladle, as with the increase in diameter and height of the ladle it is necessary to increase the number of nozzles and the pressure of the blast in order to achieve the same effect as in the small ladles. Lime is susceptible to caking which may cause an irregular input of lime and a throwing out of metal. In addition, the consumption of lime – 30 to 35 kg per t of pig iron – is very high. On treating pig iron in 80-100 t ladles, 2-4 t of lime is required and such a quantity cannot be retained on the surface of the metal; the lime will volatilize and special arrangements are necessary for its recovery. Also, it is difficult to get a large quantity of fine lime (100-500 μ); not all works are provided with nitrogen necessary for the process.

The authors consider the desulfurization of pig iron in a rotary furnace, carried out for the first time at the Novo-Lipetsk Works*, to be the most promising and effective method at present. Tests were made in two furnaces of different designs and capacities. The first furnace is shown in Fig. 2.

The removable conical part of the second furnace resembles a converter; the apertures in the furnace are tightly sealed with covers secured by means of swing bolts. The furnace is heated by means of a spray burner.

The desulfurization process in the rotary furnace is affected by the composition of the atmosphere in the furnace, the amount and particle size of lime and coke, the chemical composition of pig iron, the temperature of the pig iron, the speed of furnace rotation, and the type of furnace lining.

On conducting the process without the addition of fine coke or with the coke but without sealing of the furnace, an oxidizing atmosphere is formed in the furnace, and the desulfurization process process proceeds very slowly or does not take place at all.

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* Employees of the Works, B. Provorotov, A. Nikitin and L. Sidorin, took part in the investigation.

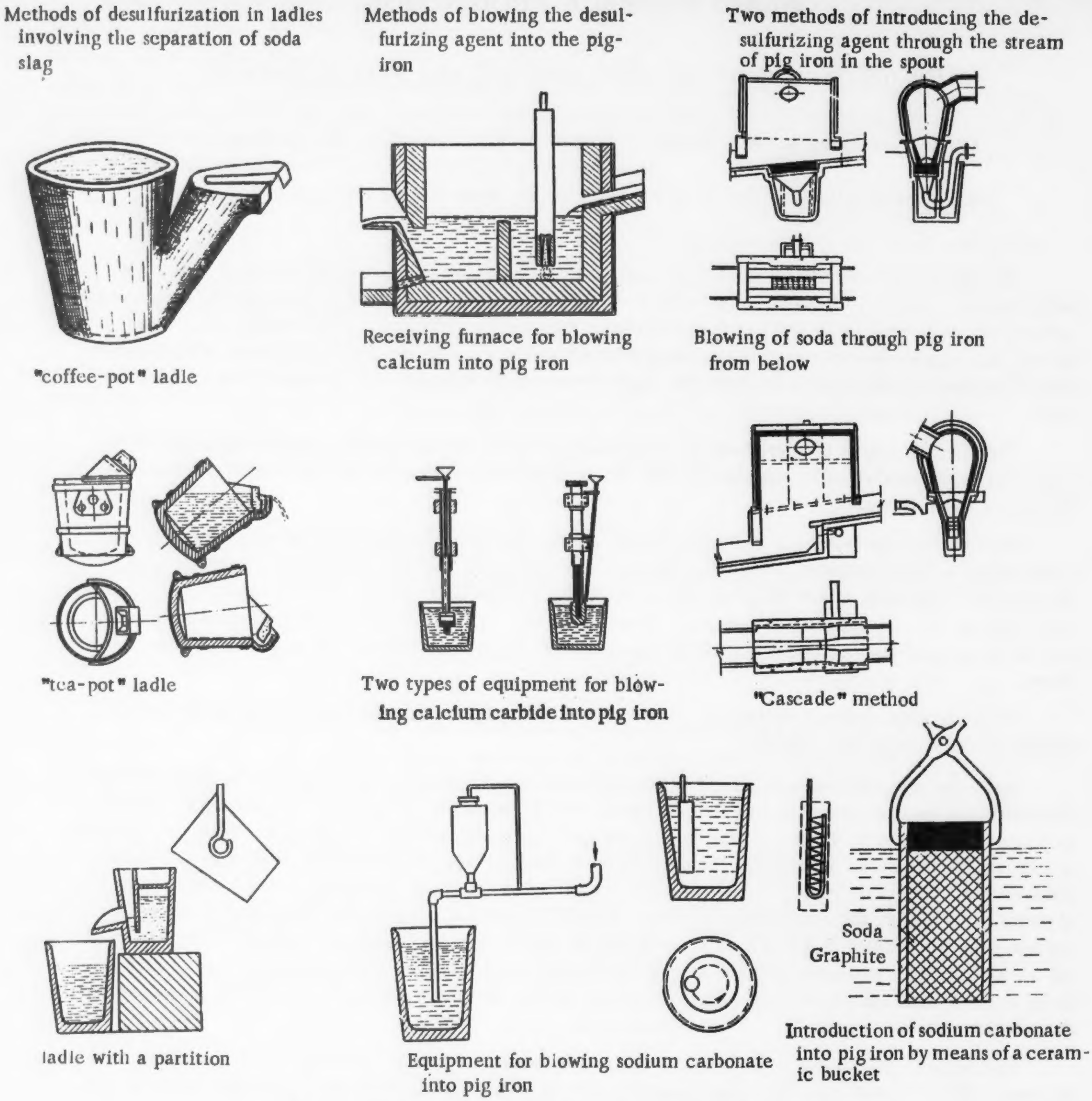

Fig. 1. Various methods of pig iron desulfurization.

Lime consumption was 6 to 20 kg per 1 t of pig iron. The best results were obtained on using 10-15 kg of lime per 1 t of pig iron. However, when hot pig iron is desulfurized, 6 kg of lime per 1 t of pig iron being used, the process lasting 5 min and the peripheral velocity of rotation being 4.4 m/sec, a low-sulfur pig iron is obtained.

The size of lime particles affects the desulfurization process. Large-size lime is less susceptible to agglomeration than the fine one but has a smaller reaction surface area and to increase it the lime input must be increased. The use of fine lime provides for a marked increase in the reaction area. The susceptibility of lime to sticking together is minimized by working with sufficiently fluid pig iron which has been first purified from acidic furnace slags. The formation of hardened slag and crust on the walls of the furnace must not be allowed because slag and crust contain a large amount of oxidized iron which promotes the formation of sticky, thick and easily agglomerating slags. On elimination of these defects and provided that a reducing

atmosphere is maintained in the furnace after the desufurization process, the lime remains fine, loose and dry.

The consumption of coke fines (1-3 mm particle size) for establishing a reducing atmosphere inside the furnace, varied between 3 to 5 kg per 1 t of pig iron. The use of coke powder caused some difficulties during the desulfurization process because coke powder possessing a great absorbing power and a large reaction surface reacts violently when the furnace begins to rotate and forms a large quantity of gases which, when escaping from the furnace, carry out lime and coke powder. This affects the desulfurization process adversely.

The chemical composition of pig iron which changed mainly in the first minutes— in particular the removal of silicon (0.1-0.15%) and partially of manganese took place— did not affect the course of the desulfurization process. The carbon content increased in the majority of the heats, hence the necessity of establishing a reducing atmosphere in the furnace on the desulfurization of low-carbon pig iron.

The pig iron fluidity which depends on temperature, has a marked effect on the desulfurization process. At an adequate fluidity the mixing of pig iron with lime is efficient, thus promoting extensive contact between the two phases and a fast process. In a thick, viscous pig iron, only the metal which is in direct contact with the lime undergoes the desulfurization reaction and the new elements of metal are brought into contact very slowly; i.e. there is no intermixing of pig iron and lime; practically all the lime remains on the surface of the metal without penetrating inside it.

The speed of furnace rotation affects the desulfurization process substantially. The tests were made at the speeds of 2.5 and 4.4 m/sec. The sulfur content in steel fell from 0.085 to 0.03-0.012% in 3-5 min. These speeds, however, were still two or three times lower than the optimum ones determined by calculations. This is seen in our nomogram (Fig. 3) for the determination of the optimum speed of rotation depending on the furnace diameter and the friction coefficient of liquid pig iron, i.e., its viscosity. On attaining the speed of 9-10 m/sec the desulfurization process may be shortened considerably.

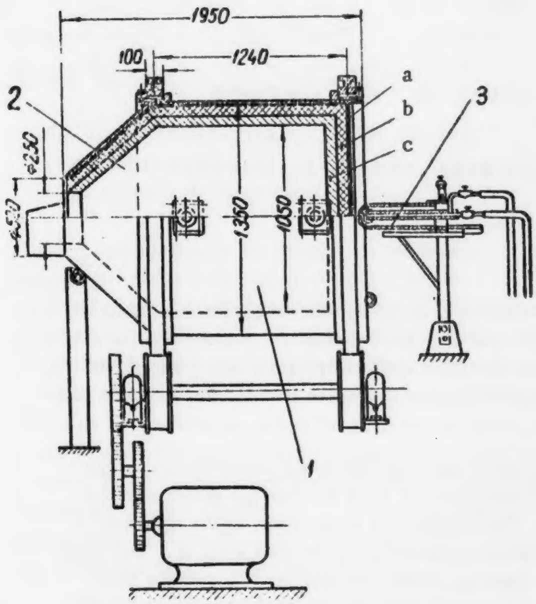

Fig. 2. Rotary furnace for desulfurization of pig iron with hard lime.
1) Furnace body; 2) removable lid with spout; 3) burner; a) sheet asbestos; b) foamy chamotte; c) chamotte.

In order to determine the effect of furnace lining on the desulfurization process, the furnace was lined in one case with chamotte and in the other with chrome-magnesite. The chamotte lining proved to be unstable against the action of lime slags and lasted usually for 10-12 charges. In Sweden, for the prevention of lining erosion a hardened layer, consisting of oxidized iron, lime and coke fines mixture in the form of a thick, sticky mass, is allowed to form. Such a layer, however, increases gradually and reduces the furnace volume. Moreover, the layer takes up a large quantity of heat from the pig iron charged and the desulfurization process deteriorates.

On operation with basic lining, the slag layer does not form and the lining is not chemically attacked.

On the basis of the tests carried out at the Novo-Lipetsk Works the method of desulfurization in the rotary furnace can be recommended to other works. For an effective desulfurization, it is recommended that lime be used with a minimum silicon and carbon dioxide content , particle size being less than 1 mm and in the amount of 1% by weight of liquid pig iron. It is necessary to establish a reducing atmosphere in the furnace by means of coke fines of 1-3 mm particle size, added in the amount of 0.3-0.5% by weight of pig iron.

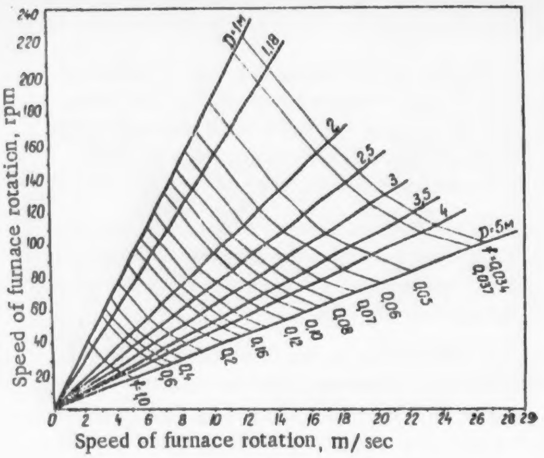

Fig. 3. Nomogram for the determination of the optimum speed of furnace rotation;
d) Furnace diameter, f) coefficient of friction.

Furnace slags and loam from spouts must be prevented from getting into the furnace together with pig iron, and the formation of a hardened slag layer and a crust on the furnace walls must also be prevented.

Editor's note. Recently a design of a rotary furnace of 100-t capacity for the desulfurization of liquid pig iron has been developed by Gipromez.

INDICATOR OF THE LIMITING WATER LEVEL IN THE SCRUBBER

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Makeevka Metallurgical Works

The high-pressure scrubber, placed after the dry dust catchers, is an indispensable element in generally accepted schemes of wet gas cleaning. When a furnace is operated at a normal pressure, water from the scrubber is removed at the rate of 600-800 cu m/hr by an overflow through a special hydraulic seal (Fig. 1) which allows the fluctuation of blast-furnace gas pressure and correspondingly of the water level in the scrubber within the limits of ± 300 mm of water.

When the furnace is operated at an elevated top-gas pressure and when there are rapid changes of the operating regime (e.g. change over to normal pressure), the fluctuations of blast-furnace gas pressure in the scrubber may reach 7000-10,000 mm of water or even more. The control of water level in the scrubber by means of self-overflow is then not possible and a float-type level regulator has to be used (Fig. 2). The float is placed in a separate chamber connected with the scrubber housing. When the level is changed the float changes its position and through a system of levers actuates the throttle. The length of the lever can be adjusted by means of a special socket joint.

Because the temperature of the water reaches 50°C and the impurities constitute up to 1500 mg/l/liter, the outlet throttle and the control mechanism quickly become covered with slime.

It causes jamming of the release mechanism and adversely affects its reliability. The operating personnel

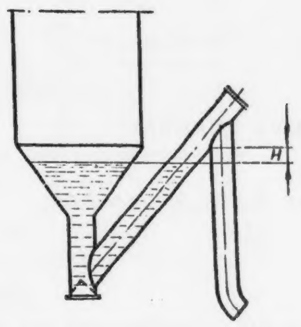

Fig. 1. Diagram of the hydraulic seal of the high-pressure scrubber: H – height of overflow.

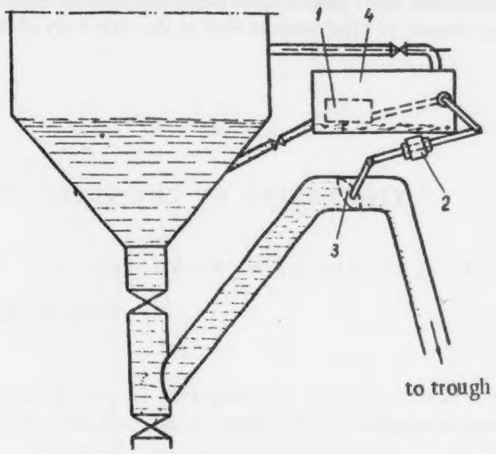

Fig. 2. Diagram showing the action of the float level regulator: 1 – float; 2 – adjusting joint; 3 – throttle; 4 – float chamber.

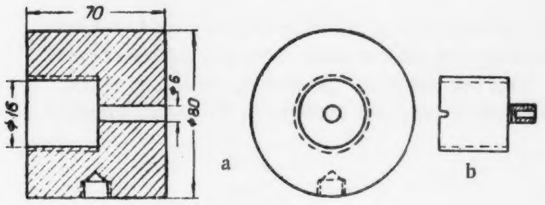

Fig. 3. Protective container for the cartridge with cobalt isotope:
a – container; b – cartridge.

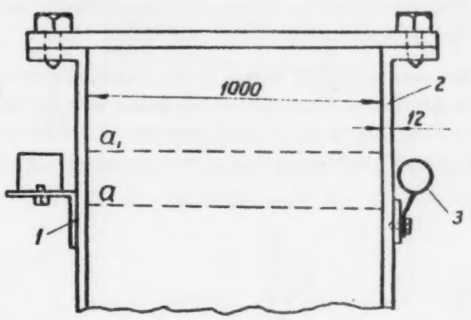

Fig. 4. Diagram of emitter and receiving tube on the float chamber:
1 – container; 2 – chamber body; 3 – tube.

has to check manually the working of the release mechanism every shift but the testing is not in itself sufficient for the normal operation of the level regulator because the water level in the scrubber is not controlled. Overfilling of the scrubber with water ("scrubber overflow") is a serious trouble. In recent years the work on the choice of an appropriate indicator of water level in the scrubber or in the float chamber was carried out at our works. In 1956 a design* for the indicator of the limiting water level in the scrubber, involving use of radioactive cobalt isotope, was developed at our works. The radioactive emitter in a protective steel container (Fig. 3) and the gas-discharge tube in a metallic housing are mounted on opposite sides of the float chamber (Fig. 4). If water in the float chamber reaches the lever α, radiation takes place through the chamber. When water reaches the level α_1, a substantial portion of the radiation is absorbed. Then a special relay switches on light and sound signals situated on the KIP board of the senior gas operator.

A cartridge which can be replaced when required is charged into the protective container.

The signalization scheme of the limiting level may be used as the basis for an automatic two-position

* G. Ia. Korshunov took part in this work.

regulator of the water level in the scrubber. This method can also be applied for the determination of the limiting amount of blast-furnace dust in the dust bags of the blast furnace.

TIGHTENING OF THE BLAST-FURNACE STOVE BURNERS

B. I. Ginzburg, A. K. Vulykh, I. I. Liseenko and D. G. Klimenko

Petrovsk Works

The heating of air in old equipment frequently involves considerable difficulties connected with the congestion of equipment, its imperfections, and low efficiency.

Because of the lack of space the gas burners of some air stoves of one of the blast furnaces at our works could not be equipped with standard separating equipment and hence there were large losses of hot air and gas between the contact surfaces of the slide gate and the stuffing box (Fig. 1). Moreover, a high content of gas in the air near the burner constituted a danger for the operating personnel.

With the object of eliminating these defects, the authors developed and introduced a mechanical stuffing box clamp with removable sleeve and cover.

For connecting the burner to the connecting tube of the gas stove (Fig. 2) during the gas period, there is a removable sleeve which is divided inside with partitions into air and gas channels. Thus gas and air are not mixed all the way to the mixing chamber of the air stove. After the end of the gas period, the sleeve is removed from the tightening ring of the clamp mechanism and is rolled away, the aperture in the connecting tube

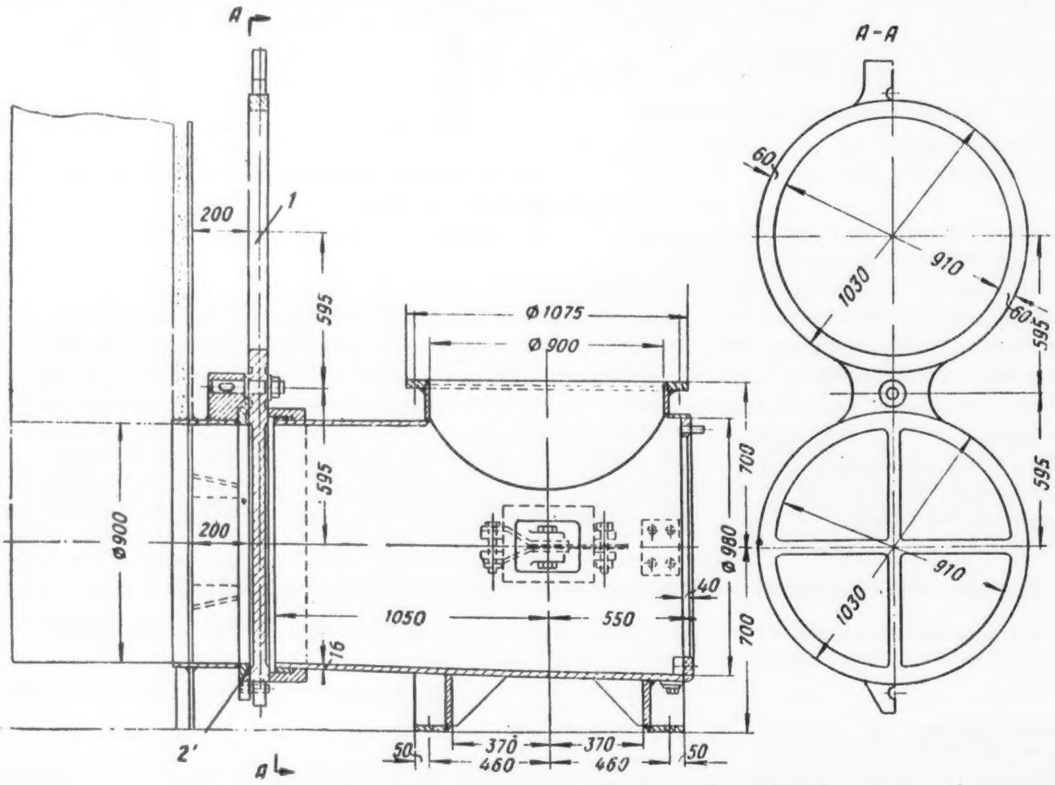

Fig. 1. Gas burner of the old design: 1 – slide gate; 2 – stuffing box.

of the air stove is covered with a lid and tightly secured with swing bolts and a hand wheel. The air stove is then changed to "on blast."

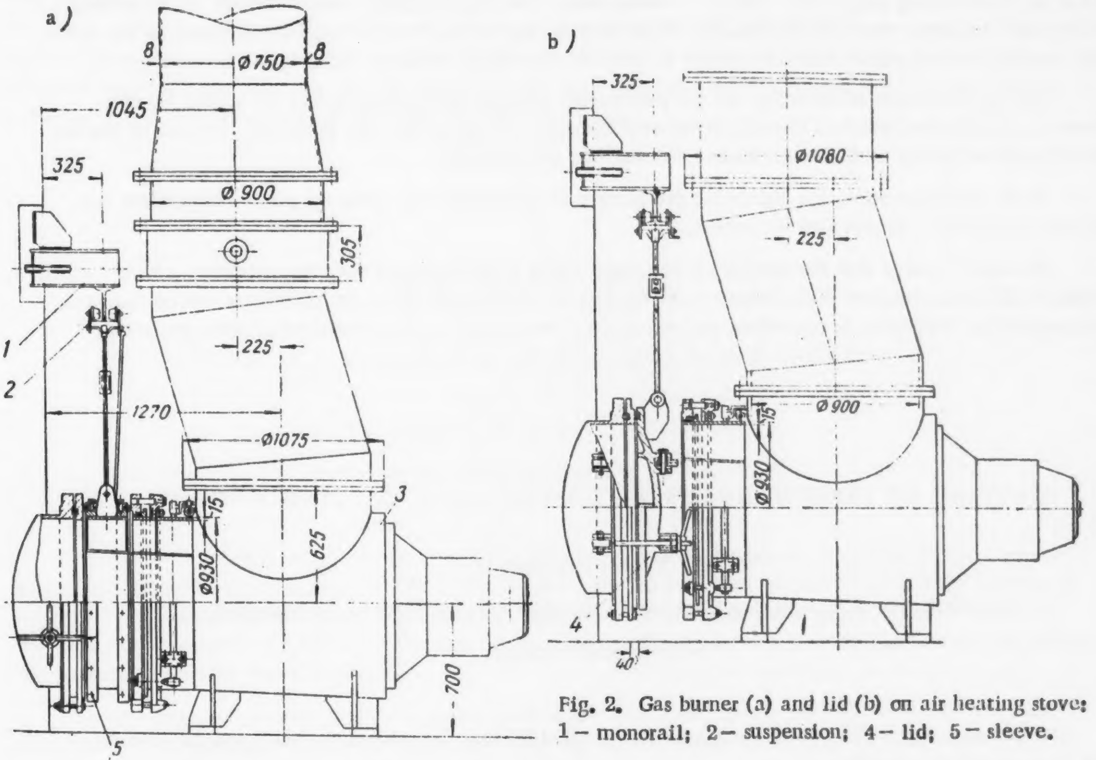

Fig. 2. Gas burner (a) and lid (b) on air heating stove: 1 – monorail; 2 – suspension; 4 – lid; 5 – sleeve.

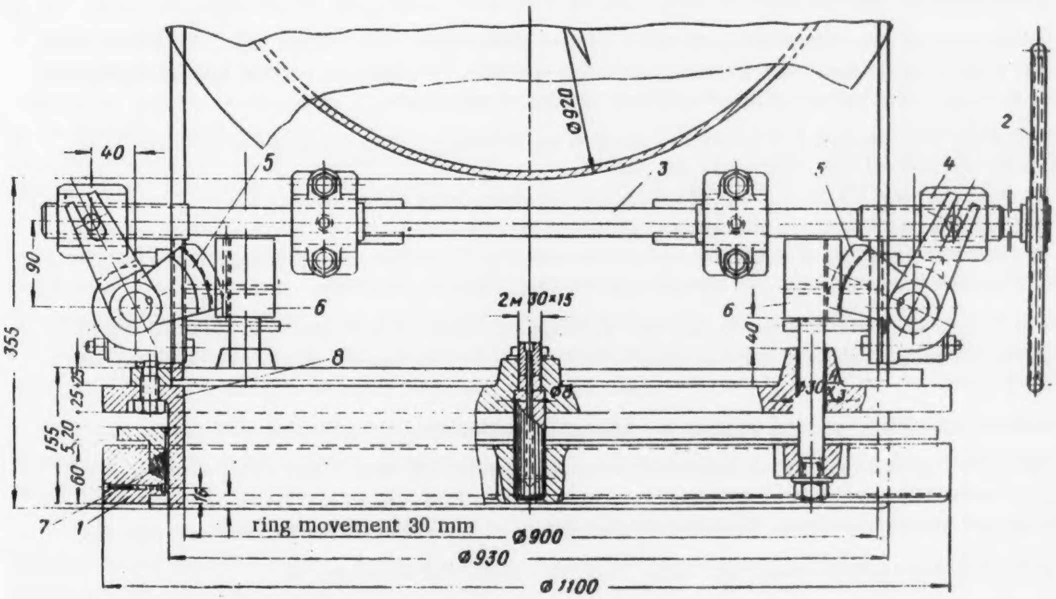

Fig. 3. Clamp mechanism:
1 – tightening ring; 2 – wheel; 3 – screw; 4 – nuts; 5 – toothed sectors; 6 – toothed rails; 7 – stuffing box; 8 – supporting ring.

The sleeve and the lid are suspended on a monorail. Asbestos rope is laid into the grooves in the lid and the sleeve, and ensures a hermetic seal when pressed against the flange of the connecting tube of the stove by the lid or by the fastening ring of the clamp mechanism. The ring is rigidly connected with the supporting rails of the clamp mechanism (Fig. 3). On an easy turning of the hand wheel, the nuts move on the screw thus moving toothed sectors which by means of toothed rails tighten or loosen the ring.

For the prevention of jamming and gas penetration between the tightening and the supporting rings, there is a stuffing box which is liberally lubricated through openings of 8.5 mm diameter. Friction in the supports is reduced owing to the bronze bushes inserted into the bearings.

To facilitate erection, the tightening mechanism is assembled away from the place of operation and then the assembly is welded into the burner.

It should be noted that the equipment described above is distinguished from the existing clamp mechanisms in IZTM burners and Frein burners (with removable sleeves and lid) by its simplicity and compactness of construction, simplicity in operation, and reliability. Hence, it may be introduced at other works too.

CASTING OF FERROMANGANESE BY MEANS OF A CASTING MACHINE

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Superintendent of the Casting Machines of the Blast-Furnace Plant at the Nizhne-Tagil'

Metallurgical Combine

At the begining of 1957, ferromanganese was smelted in blast furnace No. 2, and it was subsequently cast on a pig casting machine.

Ferromanganese was tapped into a specially allotted clean molten iron transfer ladle. During the time of transportation from the furnace to the casting machine and back, the ladle was covered with a lid consisting of two 5-mm iron plates between which there was a 50-mm asbestos layer.

Ferromanganese was cast into ordinary molds with one narrowing. With the object of reducing losses, the following optimum casting regime was adopted:

1) the molds were filled up to top, the weight of the ingots (pigs) being about 50 kg;

2) the conveyors moved at a minimum speed of 6-7 m/min;

3) a minimum quantity of water was used on the conveyor for cooling the ferromanganese so that the temperature of the ferromanganese was lowered only until solidification occurred.

With the object of softening shocks and reducing chipping, chains were suspended in the blind and tipping pits and metallic aprons were fitted above the lower end of the tipping pits, thus preventing the chips from flying about.

Flatcars with containers, used for scrap and rubbish, were employed for collecting solid pigs.

Molds were sprayed with a thick milk of lime (specific density 1.2) from freshly calcined lime. After pouring the content of a ladle, the conveyor of the machine was allowed to run for two additional cycles and was sprayed with milk of lime. Therefore the pigs did not in the least stick to the molds.

Losses of ferromanganese constituted 2.6%. They were distributed as follows, %:

"Skulls" in ladles	0.90
Scrap from the runner and splashes	0.75
Refuse, graphite and slag	0.40
Losses in pig iron storage	0.55

The containers, delivered to the casting machine, were placed on 70-t flatcars manufactured by the "Pravda" Works; a large amount of ferromanganese chips were falling through the slits in the bottom of the cars. In order to reduce losses, the containers should be placed on flatcars with a compact bottom.

The question of the durability of the molten iron transfer ladles remained unsolved. After 15-25 fillings with ferromanganese the weight of an empty ladle increases by 10-15 t, and it has to be replaced. When the ladle was used for conversion pig iron, the "skull" in the ladle was quickly removed (in 3-4 fillings); but the chamotte lining was damaged and the ladle required an overhaul.

STEEL SMELTING

USE OF MANGANESE ORE IN THE SCRAP-ORE PROCESS

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Kuibyshev Metallurgical Works in Kramatorka

The open-hearth furnace plant of our works produces carbon steel (rimmed and killed) in open-hearth furnaces in which the actual charge is 120 t. The furnaces are fired with hot producer gas of 1430 kcal/cu m calorific value containing up to 0.5% H_2S. The mean input of hot producer gas constitutes 10,000 cu m/hr, and during the charging – 12,000 cu m/hr, and this is sufficient for the furnace heat requirements of 14 million and 19 million kcal/hr respectively.

The operation of furnaces without a mixer, with sulfur-containing fuel and using 10-15 t of scrap per charge, causes a high sulfur content in metal after melting. Hence, up to 16 t of limestone has to be charged for the removal of sulfur and the slagging of silicon, and the slag has to be "broken down" with manganese ore and bauxite during melting and ore boil periods.

The introduction of large amounts of loose material of low thermal conductivity causes inadequate nonuniform heating of the charge, the formation of "skulls" during the melting period and a marked decrease in the intensity of boil because of the thick and unreactive slag. Moreover, owing to the thick layer of slag, the heat exchange between slag and metal deteriorates. The reduction in the amount of loose materials introduced into the charge constitutes a potential source of increase in furnace output and a lowering of steel cost.

With the object of increasing the furnace output, improving the process of metal desulfurization and increasing the utilization of manganese from manganese ore, experiments were carried out at our works in which 2-4 t of manganese ore were charged under the layer of limestone, the amount of loose materials – limestone and bauxite – being reduced at the same time by 4-5 t and 1-2 t respectively.

It must be mentioned that when the MnO content in slags increases, it is absolutely necessary to reduce the CaO content in order to prevent the formation of viscous slags.

There are many debatable questions amoung metallurgists specializing in steelmaking as to the effect of manganese on the desulfurization of metal, its overoxidation, nonmetallic inclusions, gas content and mechanical properties of steel.

Most metallurgists consider that the manganese reduction in the course of the heat is usually accompanied by an intensive burning of carbon, shortening of the duration of the heat and the production of a more pure steel; and the additions of manganese ore and ferromanganese in the course of the heat prolong the heat because the intensity of the boil is reduced and the metal is cooled by the additions. Hence, manganese ore should be added during the charging and not during the melting and refining periods.

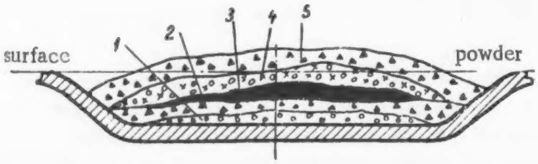
For the purpose of a thorough and detailed study of the effect of manganese ore on the furnace output, durability of the hearth, quality and mechanical properties of steel, three groups of heats were carried out in cold and hot operated furnaces:

Group I – to determine the effect of manganese ore on the durability of the hearths, 20 consecutive heats with manganese ore were carried out (in the midst of a campaign) in furnace No. 3 and 25 heats (at the end of a campaign) in furnace No. 5;

Group II – to determine the effect of manganese ore on the output of the furnace, 26 heats (with manganese ore charged during the heat) were carried out in furnace No. 3 and 14 heats in furnace No. 5;

Group III – to determine the effect of manganese ore on the technology of steelmaking and the output of the furnace, five heats were carried out with a reduced quantity of limestone and the addition of up to 2 t of bauxite instead of manganese ore.

The reduction in the amount of loose materials introduced during the charging period made possible a method of charging in such a way that the loose materials were not charged through the 1st and the 5th charging doors (see figure). Under those conditions of charging, loose materials were as if enveloped by the iron scrap which has good thermal conductivity. The loose materials were thus well heated up and favorable conditions were established for their dissolution in the liquid pig iron and the molten portion of the charge. Manganese ore was charged through the 2nd, 3rd and 4th doors prior to limestone charging in order to prevent early floating up and removal of manganese ore with the primary slag.



New scheme of charging loose materials: 1 – iron ore (5-6 t); 2 – rolled-steel trimmings (10-15 t); 3 – manganese ore (3-4 t); 4 – limestone and the remainder of iron ore; 5 – iron scrap.

The quantity of the charged materials in the test heats, the gas pressure and the air input were fixed according to the periods of the heat. Metal and slag samples were taken every hour after the hot metal charging until the charge was melted, after the melting period and before the deoxidizing period. Slags were analyzed for FeO, CaO, SiO_2, MnO, MgO and S. Then, samples were taken in the rolling plant from finished sections from the most typical heats, for mechanical testing and metallographic analysis.

On the basis of the results of the investigation, it must be noted that with regard to scrap input per heat as well as to the chemical composition of iron and the weight of the heat, the operational conditions of all the groups were practically the same.

The melting of manganese ore takes place one hour after the pouring in of liquid pig iron, which is indicated by the maximum content of MnO in the slag at that time.

Representative data from the investigation are given in Table 1.

In some heats with manganese ore, the Mn content in metal before deoxidation reached 0.4-0.45%. Basicity of the slag in the heats of both groups was the same and constituted 0.9-1.0 after the pouring in of pig iron, 1.0-1.3 before the melting and 1.75-2.0 after the melting. More sulfur (by 0.0015%) was removed from the metal in the heats containing manganese ore during the ore-boil period. There were 25% of the heats out of those with manganese ore compared with 75% of the heats out of those without manganese ore, where no sulfur was removed during the period of the ore boil. 50% of the heats with manganese ore needed the removal of one cup of slag; only 20% of the ordinary heats had this amount of slag.

It follows that because of the increased manganese content in metal, more mobile and fluid slag and a reduced slag layer in heats with manganese ore, favorable conditions are created for the desulfurization of metal during all periods of the heat in spite of the decrease in slag basicity.

MgO content in heats with manganese ore constitute 8-9% (7-8% in ordinary heats). Maximum MgO content in the heats of both groups was up to 10-11%. The length of time on furnace fettling and stoppages for hearthrepair did not increase: hence, manganese ore does not impair the durability of the hearth.

A comparison of the duration of the test heats and the heats in preceding campaigns shows that the heats with manganese ore are considerably shorter than the ordinary ones. In the main, the shortening of the heat took place on account of the melting and finishing periods. It is explained by a better heating up of the

TABLE 1

Study of Test Heats

Item	Means value in heats	
	with manganese ore	without manganese ore
MnO content in slags, %		
after melting	15-18	9-10
before deoxidation	8-11	5-8
Mn content in metal, %		
after melting.	0.16-0.22	0.09-0.12
before deoxidation	0.28-0.35	0.14-0.18
Basicity of slag before deoxidaation	1.8-2.0	2.0-2.2
S content in metal after melting, %	0.069-0.070	0.075-0.077
Percentage of heats with S content not more than 0.07%, %	65	40
S content in slags, %	0.3-0.33	0.2-0.28
Velocity of decarbonization, % C per min:		
ore boil period	0.008	0.0070
pure boil period	0.0069	0.0065

charge, the fluidity and mobility of slags, and improved conditions for the desulfurization of metal during all periods of the heat on account of an increased manganese content in metal and MnO content in slag.

TABLE 2

The Economics of the Application of Manganese Ore

Material	Saving per heat, t	Saving, rubles: - saving, +overspending
Limestone	5.0	-80
Bauxite.	0.7	-60
Ferromanganese	0.370	-380
Fuel (by shortening the heat by 40 min.).	2.0	-310
Furnace idling 40 min		-500
Manganese ore	2.0-3.0	+550
		Total − 780

In heats of the third group there was a marked drop in the output of the furnace.

The study of the quality and mechanical properties of metal showed that the elasticity, yield point and relative elongation for steel grades St. 3 and St. 5 are the same in both groups of heats. Neither did metallographic investigations reveal any definite trend; However, it must be noted that there is a smaller number of seams on the surface of metal from the heats with manganese ore and some reduction of nonmetallic inclusions.

The economic effect of the application of manganese ore is shown in Table 2.

Iron ore consumption remains almost unchanged and manganese ore consumption amounts to 20 kg/t of steel.

It should be noted, that ferromanganese consumption was 5.8 kg/t of steel in furnace No. 3 and 7.3 kg/t in furnace No. 5, while the planned quantity was 7.5 kg/t; some heats were carried out with "their own" manganese.

In September, October and November, 1957, the plant was using a new method of charging: 2-3 t of manganese ore before the limestone. The stoppages of furnaces on hearth fettling did not increase and the duration of the heat was reduced by 30-40 min. On account of the reduction of input of loose materials and deoxidizer, a saving of 144 thousand rubles was made in October and 106 thousand rubles in November.

DEOXIDATION OF LOW-ALLOY STEEL AND SAVING OF FERROALLOYS

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As a rule, the majority low-alloy steels are subjected, in the process of manufacutre, to a preliminary deoxidation of metal in the furnace with silicomanganese or ferromanganese and blast-furnace ferrosilicon. This method allows not only the deoxidation of steel but also its alloying with manganese.

The quality of steel is better if a complex deoxidizer — silicomanganese — is used. If, however, a strict procedure of adding ferromanganese and blast-furnace ferrosilicon in the preliminary deoxidation is observed, a good quality steel, not inferior to the steel deoxidized in the furnace with silicomanganese, the ratio Mn : Si being(3-4) : 1, can be obtained.

Hence, in the manufacture of low-alloy steels whose carbon content is such that it allows a preliminary deoxidation with ferromanganese and blast-furnace ferrosilicon, the above method may by considered acceptable. It should be noted that silicomanganese, especially with low carbon content, is a scarce ferroalloy.

The ratio of manganese to silicon, and the content of aluminum in the materials charged on the preliminary deoxidation of ferroalloys, have a marked effect on the content of nonmetallic inclusions, most of all oxides, in steel. The increase in the ratio of manganese to silicon and the decrease in aluminum content assist in reducing the amount of oxide inclusions which remain in steel.

With a view to lowering the consumption of silicomanganese, it is justified in several cases to replace part of it with blast-furnace ferromanganese.

On deoxidation of steels of relatively low carbon content (0.12-0.15%), it is possible to partly replace silicomanganese by ferromanganese by introducing first ferromanganese and then, after a few minutes, silicomanganese. Immediately after the introduction of ferromanganese, the bath begins to boil vigorously as a result of the rapid local increase of carbon concentration. As the experience of the Alchevsk Combine showed, a substantial part of carbon, introduced with ferromanganese, is oxidized before the introduction of silicomangananese if the above method of deoxidation is used. It must be taken into account that in this case the total loss of manganese will increase somewhat. The increase in the loss will depend on the interval between the introduction of ferromanganese and the introduction of silicomanganese.

The consumption of ferromanganese or silicomanganese in the processing of any steel may be reduced at the expense of increasing the manganese content in steel before the time of deoxidation, and by reducing the loss of manganese during the process of deoxidizing and alloying of steel. The consumption of Fe-Mn and Si-Mn is very effectively reduced if manganese ore is used. Manganese ore (0.75-1.5%) should be added after the removal of slag during the formation of secondary slag. A second (smaller) portion of ore may be introduced

at the beginning of the pure boil period, provided that the carbon content and thermal conditions of the process are suitable. A high temperature in the furnace and a small slag layer promote a better utilization of manganese from the ore.

The experience of the open-hearth furnace plant at the Alchevsk Combine, where the scrap-ore process is used shows that when 0.8-1.0% of manganese ore is added during the period of slag formation, the manganese content in the metal reaches 0.28-0.32% at about 0.1% carbon content.

The high thermal capacity of modern open-hearth furnaces reduces the effect of manganese ore additions on the frothing of slag to a considerable degree. An increased manganese content in the metal before the deoxidation makes possible, in addition to the saving of manganese, the application of ferroalloys with a lower ratio Mn:C. This fact is especially important in the manufacture of low-carbon steel with high manganese content.

The loss in burning of manganese and also of chromium (during chromium-containing steel production) depends on the residence time of deoxidants in the furnace. Other conditions being equal, the longer the residence time of ferroalloys in the furnace the higher the loss of deoxidizing elements.

N.N. Dobrokhotov recommends the calculation of the residence time of metal in the furnace by the following formula:

$$z = \frac{1.5q}{P} \text{ min.}$$

where q is the quantity of ferroalloys introduced, kg;
P is the output of the open-hearth furnace, t/24 hrs.

In the case of steel grade 19G, made in a 250-t furnace when a preliminary deoxidation with ferromanganese and blast-furnace ferrosilicon is applied, the residence time is:

$$z = \frac{1.5.6500}{570} \approx 17 \text{ min.}$$

and in case of deoxidation with silicomanganese

$$z = \frac{1.5.3500}{570} \approx 10 \text{ min.}$$

Actually, the duration of preliminary deoxidation for manganese and silicomanganese steels in 180-250 t open-hearth furnaces may constitute 10-15 min and for chromium steels 20-25 min.

The carbon content in metal before deoxidation affects the loss of manganese. From this point of view, it is preferable to use silicomanganese because in this case the deoxidation can be started at a higher carbon content.

Nowadays, the method of making killed steel without preliminary deoxidation with ferrosilicon in the furnace, i.e. tapping of steel "on the boil", is becoming widely used. Experience has shown that this method allows a shortening of the heat, a reduction of steel cost and some reduction in the content of phosphorus, hydrogen and nonmetallic inclusions in steel. Tapping of steel without preliminary deoxidation may also be very effective in the case of low-alloy steels, especially steels with low carbon and high manganese content.

According to the information of one of the works, the introduction of all the necessary manganese in the form of silicomanganese in combination with the addition of manganese ore in the course of the process, allowed a saving of about 20% of silicomanganese in the production of low-carbon silicomanganese steel. In the production of this steel, the preliminary addition into the furnace of 7 kg/t of blast-furnace ferromanganese in combination with the introduction of manganese ore in the course of the steelmaking process and of silicomanganese into the ladle, reduced the consumption of silicomanganese by approximately 35% compared with its consumption in the ordinary method of steel deoxidation.

In the production of low-alloy chromium steels with an increased silicon content, it is very appropriate to use any grade silicochromium by introducing it into the ladle, for alloying steel with chromium and silicon. The melting temperature of silicochromium is considerably lower than the melting temperature of ferrochromium and therefore the application of silicochromium facilitates the change over to the manufacture of chromium steel with tapping "on the boil". The alloying of steel with Si-Cr in the ladle allows a reduction of chromium consumption on account of a decrease in loss of chromium in burning. The high temperature of steel at the time of tapping attained in modern open-hearth furnaces into the ladle, with basic roofs makes it possible to add a large quantity of ferroalloy, approaching 20-22 kg/t, as shown by the practice of several works (Alchevsk, Stalino).

An improvement in the quality of steel and a saving of ferroalloy may also be achieved by introducing preliminarily melted ferroalloys and alloying materials into the ladle. This method necessitates special equipment for melting the additions.

As a rule, low-alloy steels are deoxidized in the ladle with aluminum, and most steels with titanium also. The amount of aluminum and titanium (ferrotitanium) depends on the grade of steel, its use and the properties required.

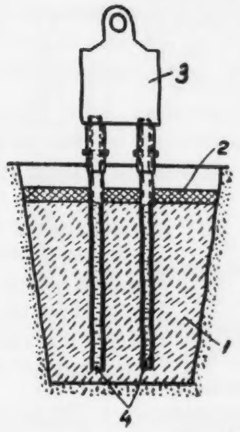
On deoxidation with aluminum, refractory alumina is produced and its inclusions to a great extent remain in the steel. The products of titanium deoxidation have a lower melting temperature and hence the nonmetallic inclusions, formed in the process, coagulate more easily and rise to the surface of the metal. Titanium and aluminum lower the tendency of steel to cold shortness and aging, the effect of these elements being bound with their ability to reduce grain size.

It is very important, especially from the point of view of weldability, to take into account the effect of aluminum and titanium additions on the lowering of the tendency of steel to grain growth at high temperature. Titanium vigorously combines with the nitrogen present in steel. Finely dispersed particles of titanium compounds forming in the process of steel solidification, constitute crystallization centers which cause the steel grain to become finer. The addition of titanium improves the mechanical characteristics of low-alloy steel, raises the yield point and the ultimate tensile strength. The optimum quantity of titanium addition should be determined for each grade of steel depending on its use and the thickness of plate or section rolled. In practice, in the production of low-alloy steel, the amount of ferrotitanium (25% Ti) introduced as the technological addition constitutes 0.75-2.5 kg/t of steel. In some low-alloy steels, titanium constitutes one of the alloying elements. In this case the necessary addition of Fe-Ti is determined by the required content of titanium in steel.

In the determination of the optimum amount of aluminum addition for a given steel, it is necessary to take into account that the increase in the quantity of aluminum causes the lowering of the fluidity of steel. This, in turn, causes an increase in the contamination of steel with nonmetallic inclusions. The problem of the quantity of aluminum addition to steel with high manganese and silicon contents should be approached with special caution. According to some data, an increase of aluminum addition to such steel causes an increase in the percentage of rejected plates due to seams.

The effect of aluminum on the reduction of grain size and the lowering of the tendency of steel to cold shortness and aging depends to a large degree on the content of metallic aluminum retained in steel, which content depends on the amount of added aluminum and the degree of its utilization. Therefore, it is necessary to thoroughly work out the method of introducing aluminum into liquid steel. The aluminum, introduced with ferrotitanium (which contains about 7% Al) and ferrosilicon, should also be taken into account.

In the commonly applied method where aluminum is introduced in lumps under the stream of metal in the ladle, the loss of aluminum constitutes 65-85%. The method of adding aluminum into the ladle by means of a rod is a very effective one. The method used in Germany, of adding aluminum to metal after a predetermined time in the ladle, may also be mentioned here. In this method aluminum, in iron tubes open at the bottom ends, is immersed in the ladle (see figure). The diameter and the number of tubes is chosen in such a way that when the required quantity of aluminum is to be introduced, the height of the tube is equal to the full height of the metal in the ladle. Tests have shown that tubes, filled with aluminum and immersed in liquid metal, begin to melt at the lower end.



Method of introducing deoxidants into metal by means of tubes: 1 – liquid metal; 2 – slag; 3 – attachment for introducing the tubes; 4 – tubes with deoxidants.

The dissolution of aluminum takes place gradually as the tubes melt. When this method of introducing aluminum was used, the amount of nonmetallic inclusions in steel proved to be considerably lower and the content of metallic aluminum higher.

NEW EQUIPMENT FOR THE EVACUATION OF LIQUID STEEL

Eng. G. A. Sokolov and Prof. Dr. Tech. Sci. G. N. Oiks

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In the steelmaking plant of the Stalingrad Metallurgical Works "Krasnyi Oktiabr'," new vacuum equipment* for the degasification of liquid steel under vacuum in the ladle, during the transfer of steel from one ladle to another placed in a vacuum chamber, for bottom pouring of steel under vacuum and for top pouring of steel in neutral and protective media, has been erected and put into operation. The weight of treated steel conforms with the charge of electric furnaces, i.e., 12 and 20 t.

The vacuum equipment consists of the following main units: pump station, chamber for the evacuation of steel in the ladle and during the transfer, vacuum chamber for bottom pouring and special molds for top pouring of steel under vacuum.

The chamber for the evacuation of steel in the ladle (Fig. 1). The base of the chamber is a cylinder of 3300 mm diameter and 2200 mm high, welded from steel plate 12 mm thick. The lid of the chamber is flat, welded and 800 mm high. The body and the lid are reinforced with ribs. Total volume of the chamber is

* The design of the equipment was carried out at the Works under the supervision and with the direct participation of the co-workers of the Moscow Steel Institute. Engineers of the Design Department of the Works, V. M. Skvortsov, V. S. Kiriukhin, M. V. Podskrebov, G. L. Kozlitin et al, took part in the design work.

25 cu m. A container of approximately 0.4 cu m volume for ferroalloys or lunkerite, a cone with an inspection aperture and the equipment for the evacuation of steel during its transfer are mounted on the lid. For the protection of the lid from overheating and for the reduction of heat losses, a two-layer steel screen is installed instead of the commonly used lining. The contact surfaces of the base and the lid are made tight with a rubber washer of 100 x 20 mm cross section.

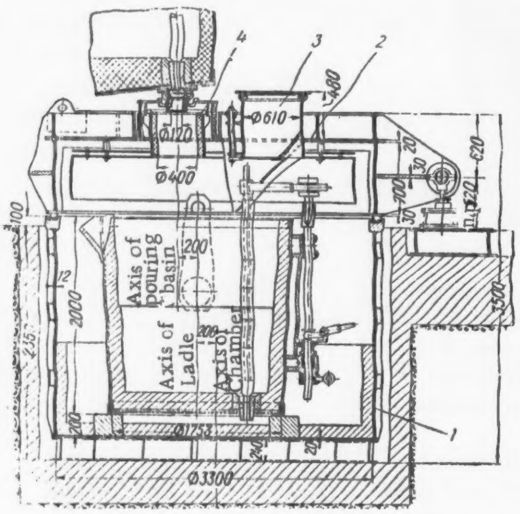

Fig. 1. Chamber for steel evacuation in the ladle: 1 – base of the chamber; 2 – lid; 3 – container for ferroalloys; 4 – transfer equipment.

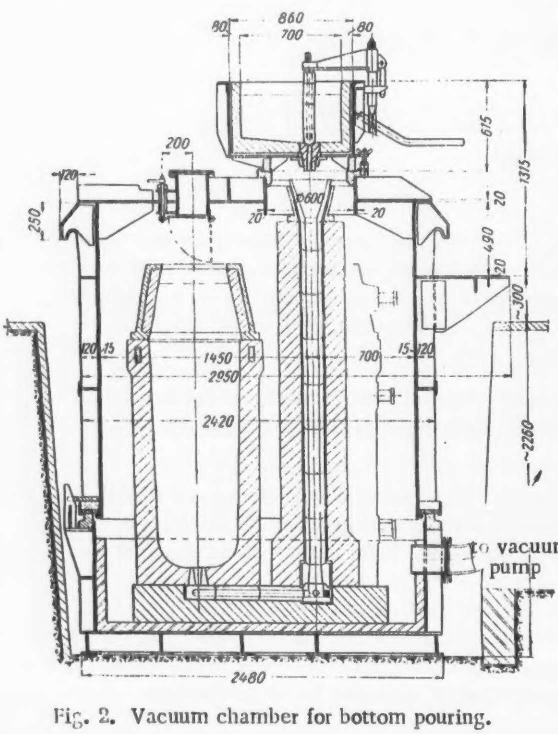

Fig. 2. Vacuum chamber for bottom pouring.

The lid of the chamber is mounted on a hinge and is lifted by means of a hoist. As a basis in the designing of the lifting mechanism, the design of a similar installation at the "Dneprospetsstal" Works was taken, with the difference that the lifting in the new equipment is effected by means of two cables fixed on the sides of the lid. Such an arrangement alows the mounting of the transfer equipment on the center of the lid. The design of the hoist has been modified accordingly.

The vacuum chamber for top pouring of steel (Fig. 2) consists of a base 800 mm high and an upper part 2100 mm high, both made of welded steel plate 12 and 20 mm thick and reinforced with ribs. The seal at the joint is provided by a rubber ring 200 mm thick, fixed to the upper part of the chamber. The chamber is designed for taking three molds and has a flattened shape which allows the placing of the chamber in the pouring pit. Three containers for lunkerite powder, an inspection hole, a safety valve, necessary on steel pouring in protective media, and an intermediate vessel in which the layer of metal serves as a liquid steal during pouring, are mounted on the top of the chamber. The upper part of the chamber is lifted and lowered by the pouring crane.

Molds for top pouring of steel (Fig. 3). Steel is poured through an intermediate vessel mounted on the hot top. In the lower part of the intermediate vessel is a outlet for pumping out gases, a container for lunkerite and an inspection hole; a special indication arrangement is provided for the control of the rising level of metal.

The central pumping station is housed in a separate brick building next to the pouring bay. The station serves the ladle evacuation and vacuum pouring sections. The pump station is equipped with two large RVN-60 multi-stage vacuum pumps. The design output of each pump at 90% vacuum is 2900 cu m/hr. Hence, two pumps in parallel can pump out more than 90 cu m of gas per min. The design of the station provides for the arrangement of the pumps either in parallel or in series. Evacuation with pumps in parallel is intended for steel tending to contain a large amount of gases; the switching-in of the pumps in series is applied for establishing a higher vacuum on treating steel with a small amount of gases.

For switching-in of the pumps in series it is

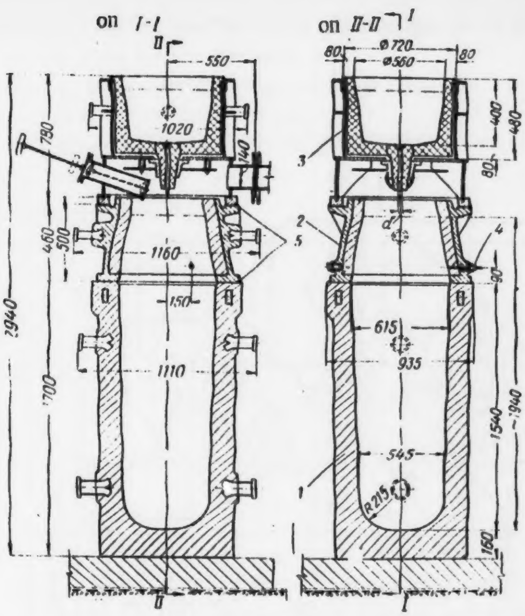

Fig. 3. Mold for top pouring of steel under vacuum:
1 – mold; 2 – hot top; 3 – intermediate vessel; 4 – level indicator; 5 – sealing coating.

necessary to close valves V and III and after starting the pumps to open valves VI (Fig. 4). On parallel operation of the pump it is just the opposite: valves III and V remain open and valve VI closed. On working in series a higher vacuum by 12-20 mm Hg, compared with the parallel operation of the pumps, is obtained. In addition, operational experience has shown that under the conditions of operation in series, the pump are easier to start than in parallel operation.

Hot gases are pumped through vacuum ducts of 200 mm diameter laid in covered-up channels under the floor of the plant. The appropriate valve (I or II, Fig. 4) is opened to connect either the ladle chamber or the chamber for vacuum pouring of steel and to establish the maximum vacuum in the system after starting the vacuum pumps.

Ejectors. The two RVN-60 vacuum pumps, when working in parallel and exhausting gases into the atmosphere, provide a maximum vacuum of about 15-20 mm Hg. At such a vacuum, the amount of the gas pumped out is equal to the amount of gas returning through the gaps between the plates and the body of the pump and through other leakages. The limiting vacuum can be improved by establishing an additional lower pressure behind the pump. For this purpose two steam ejectors (Fig. 5) are installed on the exhaust pipes behind the pumps. The main requirement in the design of the ejectors was the establishment of a preliminary vacuum of 300-500 mm Hg at relatively low steam pressures in the plant's main (3-6 atm), and at a high throughput of the ejecting medium (300-600 kg/hr).

Both ejectors were made at the works. Inlet chambers and throats were made from cast steel, and diffusors welded from plate steel. An accurate finishing of the inlet chamber of the ejector ensured a good alignment of two main components of the ejector – the nozzle and the throat – after the assembling.

The ejector was tested in order to obtain its characteristics. The ejector was mounted horizontally with the suction inlet upward the steam flange of the ejector was connected to the steam main which was provided with a valve and a manometer for the control of steam pressure. The suction inlet of the ejector was covered with a flange which had a polished projected area with an aperture of 70 mm diameter. For measuring the rate of ejected medium, the aperture was covered with plates having calibrated orifices of 7, 15, 22, 30 and 40 mm diameter.

In the course of the investigation, the effect of steam pressure and of the rate of ejected medium (air) on the degree of vacuum established by the ejector, was studied. Tests were made at various steam pressures within the limits 1 to 6.5 atm. After the steam pressure was set at a fixed value (by means of the steam valve), the obtained vacuum at various rates of ejected medium was measured. Maximum rarefaction for each steam pressure was obtained on covering the aperture with a blind flange. The vacuum established by the ejector was measured by a spring manometer mounted on the same flange.

The rate of ejected medium was determined by the formula

$$G = 3600 \cdot \mu \frac{\pi d^2}{4} \gamma'_a \cdot \sqrt{2gH_{Hg} \frac{\gamma_{Hg}}{\gamma_a}} \quad \text{kg/hr}$$

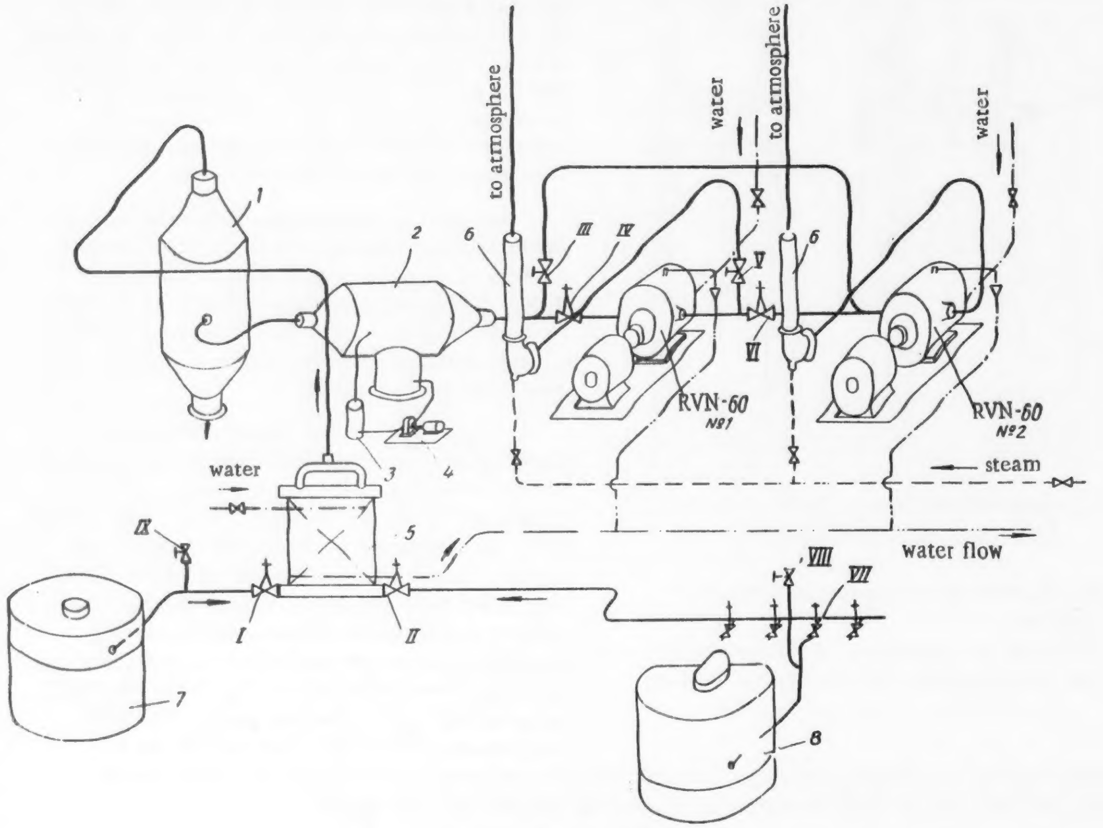

Fig. 4. Diagram of vacuum plant; 1 – dust separator; 2 – oil filter- 3 – oil cleaner; 4 – oil pump; 5 – cooler; 6 – steam ejector; 7 – ladle chamber; 8 – chamber for bottom pouring of steel; I – IX – vacuum valves.

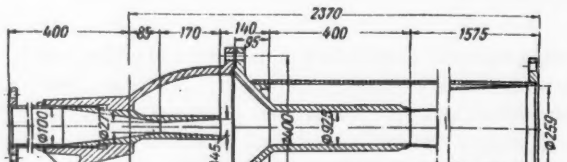

Fig. 5. Steam ejector.

where μ – orifice coefficient for given orifice ($\mu = 0.61$);

d is the orifice diameter, m;

γ_a is the specific weight of air at t deg C;

H is the vacuum, mm Hg

γ_{Hg}, γ_a is the specific weight of mercury and air respectively.

Results of Ejector Tests

Steam pressure P_1^*, atm	Orifice diameter d_1, mm	Vacuum H_{Hg}, mm Hg	$\sqrt{H_{Hg}}\,(\text{m. Hg})^{\frac{1}{2}}$	Rate of air flow, kg/hr.	Steam pressure, P_1^*, atm	Orifice diameter d_1, mm	Vacuum H_{Hg}, mm Hg	$\sqrt{H_{Hg}}\,(\text{m. Hg})^{\frac{1}{2}}$	Rate of air flow kg/hr
	0	60	—	0		0	350	—	0
	7	58	0.242	11.6		7	345	0.588	28.1
	15	57	0.239	52.4		15	330	0.575	126.2
1.0	22	55	0.235	110.0	4.0	22	325	0.570	267.0
	30	48	0.219	191.5		30	310	0.558	488.0
	40	45	0.213	332		40	290	0.530	825
	70	35	0.187	890		70	210	0.458	2190
	0	165	—	0		0	440	—	0
	7	160	0.403	19.3		7	430	0.657	31.8
	15	158	0.398	87.3		15	425	0.653	143.5
2.0	22	145	0.381	178.5	5.0	22	410	0.641	301
	30	137	0.371	325.0		30	390	0.626	548
	40	130	0.361	562		40	365	0.605	942
	70	90	0.300	1430		70	270	0.520	2480
	0	200	—	0		0	560	—	0
	7	195	0.442	21.0		7	530	0.728	34.8
	15	193	0.440	96.5		15	505	0.713	157
2.5	22	185	0.432	202.0	6.0	22	475	0.690	323
	30	175	0.418	367.0		30	455	0.676	592
	40	165	0.407	633		40	415	0.645	1005
	70	125	0.356	1700		70	280	0.530	2530
	0	245	—	0		0	580	—	0
	7	240	0.490	24.4		7	570	0.756	36.0
	15	235	0.486	106.5		15	560	0.750	165.0
3.0	22	230	0.480	225.0	6.5**	22	525	0.725	340
	30	220	0.470	413.0		30	490	0.700	613
	40	205	0.453	705		40	450	0.672	1050
	70	150	0.388	1850		70	290	0.540	2580

* Steam temperature = 200°C.

** Maximum steam pressure in the mains during tests.

After some transformations, the formula $G = 97.4\,d^2 \sqrt{H_{Hg}}$ was obtained and it was used for the calculation of the rate of ejected medium for all the points on the diagram (Fig. 6). It is seen from these data that for the ejector of the design under tests, the attained vacuum depends greatly on the steam pressure and to a smaller degree on the rate of the ejected medium. For instance, when at the same air flow rate (1000 kg/hr) the steam pressure is increased from 3 to 4 atm, the final pressure falls from 280 to 285 mm Hg, while at 4 atm steam pressure the flow rate of the ejected medium has to be increased from 0 to 1600 kg/hr in order to attain such a change in pressure (95 mm Hg). Maximum vacuum attained during the test of the ejector at 6.5 atm steam pressure was 580 mm Hg.

In the layout of the station, the ejectors are placed behind the pumps. They take up the gases from the pumps and eject them into the atmosphere through vertical tubes 20 m high. The introduction of the ejectors made possible an improvement in vacuum, on parallel operation of the pump and at not more than 4 atm steam pressure in the plant mains, by 5-10 mm Hg. The vacuum established behind the pumps was 300-350 mm Hg. At an increased steam pressure there should be a substantial improvement.

It must be pointed out that when vertically mounted ejectors are used during cold seasons of the year, a thorough separation of condensate must be ensured in order to prevent water from getting into the exhaust tubes of the pumps. Good results can be achieved with an appropriate insulation of of the steam pipes and outlet pipes. In this respect, the horizontal mounting of ejectors may be regarded as a better method but unfortunately it was not possible to use such an arrangement in the described equipment.

Valves. In order to attain an adequately high vacuum in a relatively complex system with several valves, particular attention had to be paid to the valve design. Original slide valves (Fig. 7) with sealing rings ensuring a good seal and a minimum resistance to the gas flow, were designed and made. The components of valve housings were made of cast steel and were sand blasted and machined; the slides were polished and chromium-plated. After unsuccessful attempts to use sealing rings of textolite, leather and rubber, paranite rings, which gave the best results, were accepted. As the slide valves proved to be satisfactory in operation, we consider it necessary to describe the method of making paranite rings because without reliable sealing rings the valves described may be found useless in practice.

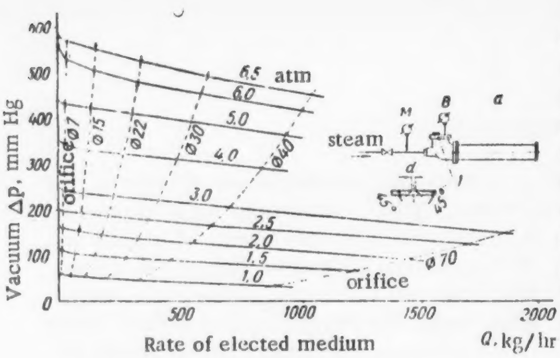

Fig. 6. Characteristics of ejector:
a – diagram of ejector test; 1 – test disc with orifice.

To prepare these rings, sheets of paranite 1.5-2 mm thick are out into strips, their surface is polished with emery and the short strips are made into one long piece by means of rubber solution. The strip is then covered with hot vulcanizing rubber adhesive and is wound on a lathe onto a wooden cylinder of the same diameter as the internal diameter of the rings, a special tightening roller being used for pressing the strip. After the winding of the cylinder, it is vulcanized and exposed to a temperature of 120-140°C for two hours. The cylinder is cut on the lathe into rings of the required width and the wooden core is drilled out.

The internal and external surface of the rings is polished with an emery grinder. Prior to insertion into the grooves of the valve housing, the sliding surface of the ring is rubbed with graphite. The paranite rings ensure a good seal of the valves and a sufficiently easy movement of the slide. In the closed and the open positions the recess of the valve housing is separated from the vacuum duct. This improves the conditions for establishing vacuum.

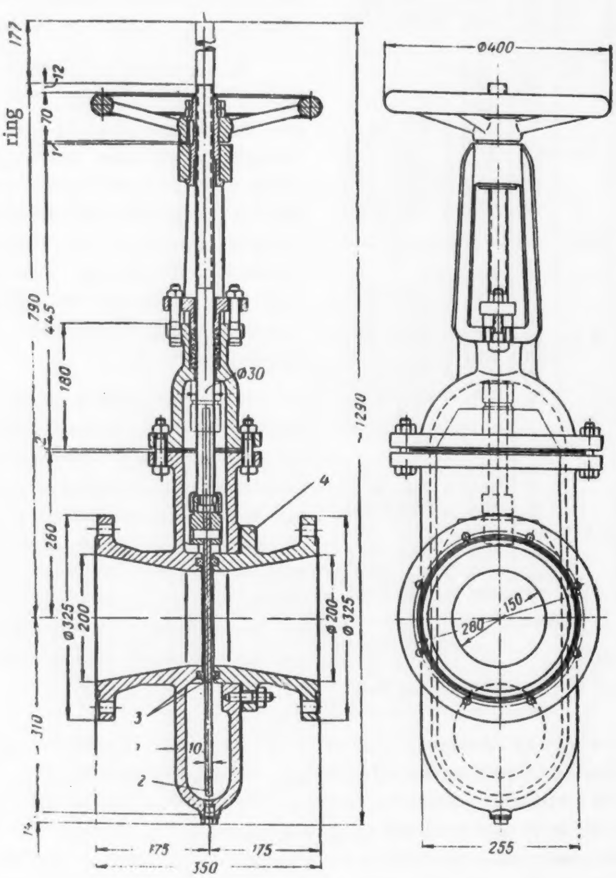

Fig. 7. Vacuum valve:
1 – valve housing; 2 – slide; 3 – sealing ring; 4 – housing flange.

C o o l e r. For cooling of evacuated gases, there is a flat tube cooler with about 3.2 sq m cooling surface. The gases pass through tubes which have a water jacket on the outside. Gases and water flow on a counter-current principle.

D u s t p r o t e c t i o n i n p u m p s. The RVN-60 pumps must not pump dusty gases and therefore a two-stage cleaning of gases is provided for in the station. After leaving the cooler, the gases first pass through an inertial dust separator (Fig. 8) consisting of a vertical cylindrical shell inside which two grids of stainless steel strips are mounted. The evacuated gases move down the space between the grids, and, turning through 160°, pass between the strips and enter the vacuum duct. Dust particles having a larger inertia than gases fall into the lower part of the dust collector where a hatch is provided for periodic dust removal. During the operation, it was found that mainly large particles of dust, slag and scale of 0.1-1.0 mm size settle in the dust collector.

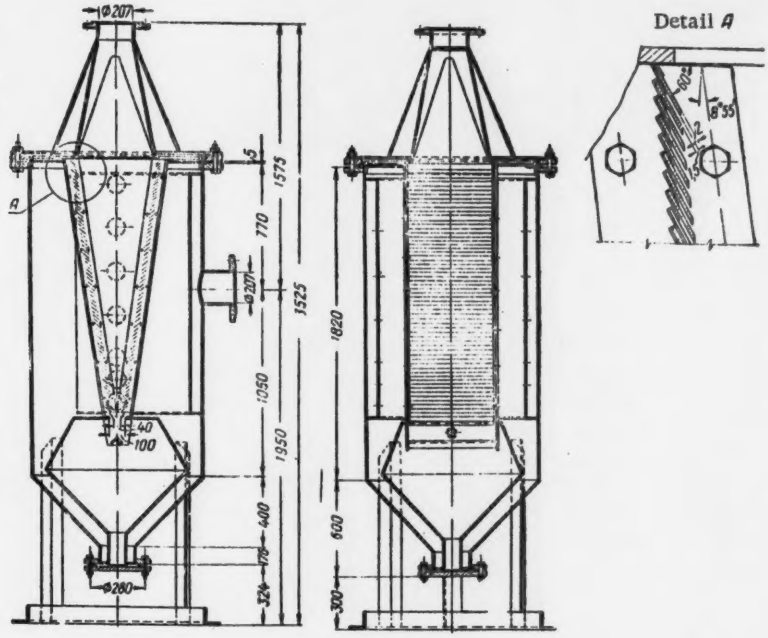

Fig. 8. Inertial dust separator.

For a more thorough gas cleaning, an oil filter with a forced oil circulation is installed. The filter is filled with the spindle oil (about 100 kg) which is of relatively low viscosity and low volatility under vacuum. Tests showed that spindle oil lost 2.5% of its weight in one hour on evaporation from a flat cup in vacuum (1 mm Hg) at 90°C. Transformer oil lost 24% of its weight under the same experimental conditions.

The vacuum equipment was put into operation in November, 1957. In the first period of operation the performance of all units was satisfactory. Even the evacuation of vigorously boiling heats in the ladle took place at 12-14 mm Hg final pressure in the chamber.

VENTILATION OF THE OPERATOR'S CAGE ON STRIPPING CRANES

In the mold preparation plant of the Cheliabinsk Metallurgical Works, freon ventilation equipment (designed for operation at a temperature of outside air not above 55°C) was used at two stripping cranes. In summer time the temperature of the crane operator's place reaches 60-70°C. This equipment, which was, in addition, of an unreliable design, was frequently breaking down and hardly contributing to the improvement of the operator's working conditions.

In 1957, in place of freon equipment, ventilation equipment with a coke-water filter (see drawing) was installed at these cranes.

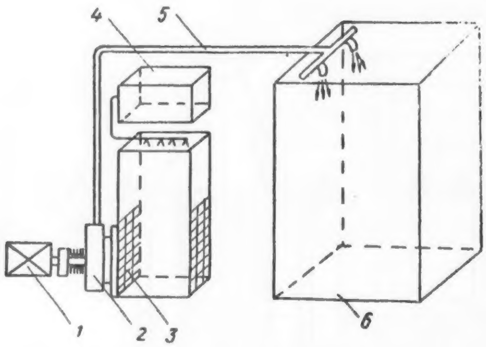

Diagram of ventilation equipment: 1 – electric motor, N = 1.3 kw; 2 – fan No. 3; 3 – coke-water filter; 4 – water tank; 5 – air duct; 6 – operator's cage.

Air is taken in from the stripping section by a fan and is drawn through the coke-water filter, a chamber 750 x 750 x 1400 mm where coke is sprayed continuously with water. The air is cleaned and humidified in the filter and passes through a rectangular duct into the operator's cage. Water for the moistening of the coke is supplied through a pipe from a special tank filled at the beginning of each shift.

For an effective operation of the equipment, a good thermal insulation of the components – the fan, the filter, the tank for water with ice and the air duct – is necessary.

G. I. Ezenkin.

EFFICIENT PASS DESIGN FOR ROLLING HEXAGONAL STEEL SECTIONS

Cand. Tech. Sci. A. A. Nefedov and B. M. Iliukovich

Scientific Co-worker of the Ural Institute of Metal, Senior Roll Designer of the Chusovsk Metallurgical Works

Hexagonal steel section for nuts and bolts can be rolled according to any of the four arrangements shown in Fig. 1.

The first arrangement is characterized by two special passes and the position of the roll joint in the finishing pass half way up the side walls. This arrangement ensures a proper filling of the corners of the section and the correction of width variation in the course of rolling. The change in width has little effect on the dimension of the section. Because there are only two special passes, on switching over to rolling of a different section in the case of common roughing passes the time for roll changing can be reduced.

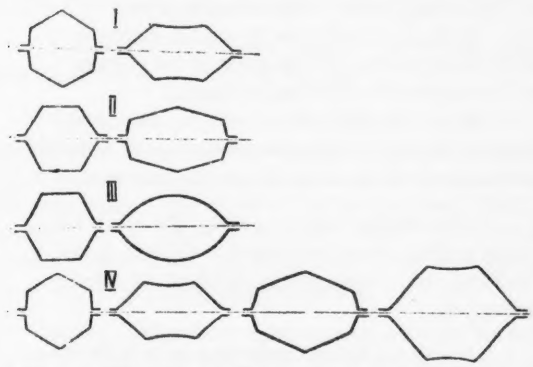

Fig. 1. Diagram of roll passes for hexagonal steel section.

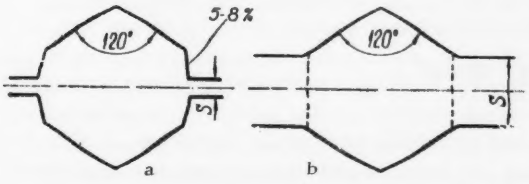

Fig. 2. Finishing pass for rolling hexagonal steel section: a – usual design; b – new design.

In the second arrangement, there are two special passes and the finishing pass is designed in such a way that two corners of the section are at the roll joint. When the section is rolled according to this scheme, it is difficult to get well defined corners of the section in the joint of the rolls because of the variation in the width along the piece. An advantage of this arrangement lies in the similarity of finishing and prefinishing passes, as the nonuniformity in the draft in the finishing pass is reduced.

The third arrangement of passes is a modification of the second, the special pre-finishing pass being replaced by an oval pass. There is an increased nonuniformity in the draft and an unstable positioning of the piece in the finishing pass.

The fourth arrangement involves four special passes, thus reducing the nonuniformity in the draft in the passes and ensuring constant well-defined corners and dimensions of the section. The adjustment of the mill, however, is made difficult; furthermore, a change over to a different section entails additional time losses.

The difficulty in obtaining well defined corners in the section rolled according to the second or third arrangement, the large number of special passes in the fourth arrangement and other disadvantages, limits the application of these passes.

The most effective arrangement is the first one which ensures product of constant dimensions, relatively easy adjustment and a high output of the mill. The finishing pass is designed in the form of a regular hexagonal section whose dimension is determined by the inscribed circle; all angles are 120° (Fig. 2a). In the determination of the pass dimensions, the standard tolerances for the section should be taken into account (Table 1).

The side of the pass is usually given a slope of 5-8% to ensure a free movement of the piece and to limit the fluctuation in the spread of the sides of the section. The absolute value of the side spread, even at a minimum slope of 5%, reaches a considerable width laterally (1.5 mm or more) in large hexagonal sections. Filling up of the pass causes breaks in the side walls of the section with consequent defects in its subsequent treatment.

TABLE 1

Permissible Deviations in the Dimensions of Finished Hexagonal Rolled Section GOST 2879-51

Dimension size of hexagonal section	Permissible tolerances			
	ordinary accuracy		increased accuracy	
8—9	—		+0.1	—0.3
10—19	+0.3	—0,5	+0.2	—0.3
20—25	+0.4·	—0,5	+0.2	—0.4
26—48	+0.4	—0,75	+0.2	—0.6
50—58	+0.4	—1,0	+0.2	—0.9
60—70	+0.5	—1,1	+0.3	—1.0

TABLE 2

Dimensions of Pre-finishing Pass for Hexagonal Steel Section

Dimensionof hexagonal section, mm	Dimensions of pre-finishing pass, mm				
	h	*m*	*x*	*b*	*s*
7—12	*d*—(1.2—1.6)	*h*— .2—0.4	1.3 *t*	2 *x*	1.5—2.5
13—20	*d*— (1.7—2)	*h*— (0.6—1.0)	1.3 *t*	2 *x*	2.5—3.0
21—80	*d* — (2—2.5)	*h* —	1.3 *t*	2 *x*	3.5—5.0

Annotation: d – diameter of the section; t – side of the hexagonal section.

Experience has shown that the necessary accuracy in the outline of the side walls of a finished section, when free lateral spread is allowed in rolling, is ensured by appropriate pre-finishing passes (more frequently edge passes).

For rolling hexagonal steel section, a new finishing pass design has been developed (Fig. 2,b) in which a free side spread is allowed. Such a pass has the following advantages over the conventional pass design:

1) It allows rolling of hexagonal sections of different dimensions (16-24 mm) in the same pass by the adjustment of the distance between the rolls; it reduces the roll cost and increases the output of the mill because of time saved on roll changing.

2) It allows an increase in the number of passes at the same barrel length of the rolls, owing to the reduced collar width between passes.

3) It permits the use of smaller diameter rolls, owing to the reduced depth of the grooves – the durability of rolls being enhanced.

4) It simplifies the work of the machining shops on turning grooves and preparation of templets, and needs a smaller stock of templets and tools.

Well-defined corners and straight side walls of the section, when free spread is allowed in the finishing pass, depend on the design of the pre-finishing pass.

At the All-Union Conference on Roll Design for high grade steel rolling, it was recommended that a pre-finishing pass as shown in Fig. 3 and Table 2 should be designed. The value $\frac{h-m}{2}$, is very important as on it depends the filling of the side walls and corners of the section. The convexities of the pre-finishing passes for hexagonal section of 10 to 12 mm, based on the practice of Chusovsk Metallurgical Works, are given below:

Size of hexagonal section, mm	10–19	20–24	26–34	35–42
Convexity $\frac{h-m}{2}$, mm	0.3	0.4	0.5	0.6

It is seen that in rolling hexagonal section in a finishing pass where free side spread is allowed, a larger convexity than that recommended by the Conference is required.

It is advantageous to reduce to 38-42°, for a better filling up of the vertical corners of the section, the inclination angle (usually 45 deg) of the side walls of the pre-finishing pass. Such a design of the pre-finishing pass makes it possible to use the same pass for rolling sections of two or three different sizes.

When the roughing passes are chosen, account should be taken of the characteristic features of the design and operation of the mill, the assortment of sections and the degree of mechanization and automation.

Some home works achieved good results in rolling hexagonal section according to the following scheme: square – slab – edge – pre-finishing hexagonal – finishing hexagonal pass. At the same time, a simple scheme is also used: square – pre-finishing hexagon – finishing hexagon. Here, the shape of the square with rounded-off corners approaches, to a certain extent, the shape of the section after the edging pass.

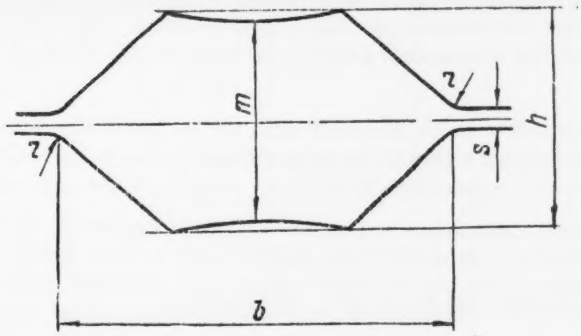

Fig. 3. Design of pre-finishing pass for rolling of hexagonal steel section.

Therefore, the passes preceding the hexagonal pass should be square or edging. The use of oval passes causes additional difficulties in holding oval section in the pre-finishing pass and shows an unfavorable effect on the dimension accuracy and the quality of the section.

Square, edging and oval passes allow for the rolling of two, three or more sizes of sections in the same pass by raising or lowering of the roll.

At our works, the hexagonal sections are rolled in three lines on a 250 mill. 100 mm square billet is rolled in five passes on the cogging stand down to 43 mm and is transferred to a roughing train where it is rolled in three passes. The finishing train consists of seven two-high stands with rolls of 270 mm diameter and 550 mm barrel length made of chilled cast iron. Hexagonal sections of 10 to 24 mm are rolled on a 250 mill according to the following scheme; square – pre-finishing hexagon – finishing hexagon. The choice of this scheme conforms with the method of rolling other sections on this mill. The systems – oval – square and rhombus – square constitute roughing passes.

Seven stands of the finishing train are used for rolling 10-12 mm hexagonal sections, five for rolling 13-15 mm and three for rolling 16-24 mm hexagonal sections.

The hexagonal section is rolled from free-cutting steel A12 and high quality steels, grades 40-45. Total elongation on rolling from the square to the final section is within the limits 1.43-1.93. Separate elongations from the square to the pre-finished hexagon are 1.31-1.57, and from the pre-finished to the finished hexagon 1.14-1.36.

The new design of the finishing passes made it possible to have only two sizes of finishing passes for rolling of all types of hexagonal steel sections. A set of rolls with eighteen equal passes serves for rolling 10-15 mm hexagons, a set with twelve passes – 16-24 mm hexagons. The operational experience on the 250 mill shows that the adoption of finishing passes of the new design ensures the production of high quality hexagonal sections with sharply defined corners and satisfactory side surfaces. Moreover, the output of the mill increased and the consumption of the rolls fell.

MATTER FOR DISCUSSION

PREVENTING INDENTATIONS ON WORKING ROLLS

Cand. Tech. Sci. I. M. Meriin

During cold rolling of steel strip, indentations appear on the rolls as the result of pressing-in of the ends of the strip or of some extraneous particles into the roll barrel. The indentations impair the surface of the strip and affect the accuracy of the thickness as the height of the resulting impressions on the strip is sometimes 0.02 mm or more. The indentations on the rolls shorten the service life of the rolls between the remachining and hence lower the productivity of the mills.

From the practice of works it was found that on rolling of steel strip with single reduction of 10-15% and total reduction of 30-40%, there was only a small number of indentations on rolls made of 9Kh steel (roll hardness 95 units on the Shore hardness scale). During rolling with the same reductions on nonreversible six-roll mills, the working surface of the rolls is rendered unfit, on the average, after one shift of operation. During rolling with the same single reductions but a higher total reduction (reduction by working up to 60-75%), the indentations appear in considerably larger number and therefore the working surface of the rolls is rendered unfit after approximately three or four hours operation. At the same time the amount of strip with marks from indentations increases substantially.

When the total reduction is increased to 60-75% and simultaneously the single reductions are increased to 20-30%, the indentations on the rolls appear after almost each strip coil. Under these conditions the rolling of high quality strip is very difficult.

The pressing-in of strip ends into the working rolls is caused by an excessive resistance of rolled metal to deformation on entering into, and, in particular, on leaving the rolls. The very great resistance of metal to deformation on entering and leaving the working rolls is, in its turn, connected with the excessive strain of strip ends (over a zone of a few millimeters).

In order to prevent indentations on rolls, preliminary tapering of the ends of the strip, strengthening of the springs of the suspension support of the upper working roll and the fitting of springs between the upper and the lower bearings was attempted. No satisfactory results, however, were obtained (the indentations caused by the strip ends still appeared at the single reductions of the order of 15-20%.

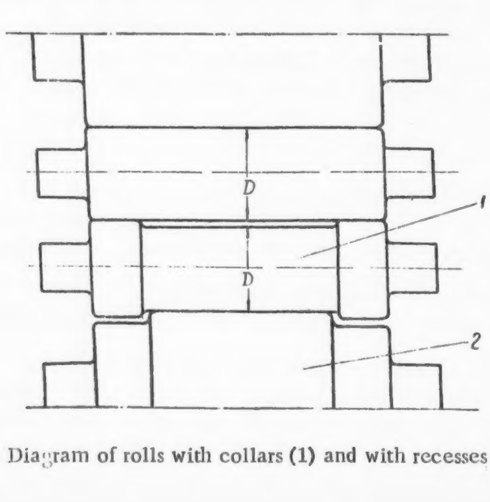

Diagram of rolls with collars (1) and with recesses (2).

Then, trials were made of rolling the strip with rolls of 6/125 and 6/160 six-roll mill. Collars, 35-40 mm wide and 0.20-0.25 mm high, were made at the ends of the roll barrel of one roll; the backing-up rolls had corresponding recesses (see figure).

Tests carried out showed that the use of rolls with collars prevents the formation of indentations caused by the strip ends during rolling with total reduction up to 70-75% and single reductions up to 20-25% and, in some cases, up to 30%. When, however, single reductions are increased to 35-40% or more, the indentations from the ends of the strip appear again. For

rolling with such reductions, it is necessary to tighten the rolls and hence reduce the gap between the working rolls at the moment of strip entry. At those reductions (35-40% or above) it is necessary to increase either the width or the height of the collars without, however, allowing their contact with the barrel of the second roll during the strip rolling.

The other method of preventing strip end impressions – by means of loosening the rolls – on the entry of strip into the rolls should not, in our opinion, be recommended as on the subsequent compression of the strip, the pressure on the rolls, which is already very high during rolling at high reductions, rapidly increases.

Presently, on all the six-roll mills at the works, the strip of carbon steel and alloy steel, 0.45-0.5 mm or more thick from hot-rolled sheet 2.0-2.5 mm thick and 96 mm wide, is rolled with rolls of which one has collars 0.25 mm high and 40 mm wide. When thinner than 0.45 mm strip is rolled, it is recommended to use rolls with collars of height equal to half the thickness of the strip rolled. The collars, moreover, prevent the adhering of metal particles from the strip ends onto the rolls.

During the cold rolling, extraneous particles, usually not exceeding a few tenths of a millimeter, get on to the rolls and the strip. When such a particle gets between the working roll and the strip, it is pressed into the strip without leaving a noticeable impression on the roll. When, however, such a particle falls on the contact surface of two working rolls (during an idle run) or on the contact surface of the back-up roll and the working roll, it causes the formation of indentations.

It is found, from the analysis of the process of particle penetration into the surface layers of the back-up and working rolls, that the harder the particle and the backing-up roll the smaller the thickness of the particle necessary to cause the formation of indentations on the working roll. The increase in rolling pressure also acts in the same way, but its effect is so small that it remains practically undetected.

The tests showed that with the increase of single and total reductions the depth and the number of indentations increases. This was connected with an increase in hardness and the amount of particles which break off, during the rolling, from the edges of the strip and from scabs and seams on the strip and get between the backing-up and working rolls. The formation of this kind of indentation was almost completely eliminated by lowering the hardness of the backing-up rolls on all six-roll mills of the works from 90 to 60 Shore hardness units by means of tempering hardened rolls at 460-480°C. True, during the operation, the hardness of the rolls increased by about 10 Shore hardness units.

The investigation carried out made it possible to roll some strip sizes from steels 10, 30, 50, 70S2KhA, 20Kh and 10G2 at single reductions of about 25% and a total reduction of 70-75%, and from steel U10A at a total reduction of up to 60-65%.

The adoption of rolls with collars and the decrease of hardness of the backing-up rolls resulted in a substantial decrease of faulty strip due to indentation marks. For instance, faulty production in the gramophone strip (St. 70S2KhA) was 1% prior to the adoption of these measures, and was then reduced more than 10-fold.

On rolling by the new method, the working surfaces of the rolls last on the average for more than one shift, i.e., the service life of rolls remained approximately the same as on rolling by the old method of 10-15% single reductions and 30-40% total reduction.

ELIMINATION OF DENTS IN RAIL-JOINT BARS

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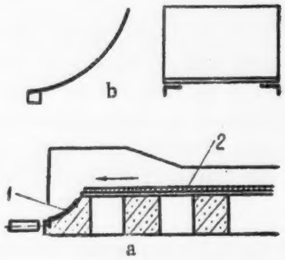
The surface condition of the parts which are used under reversible stresses has a substantial effect on their serviceable life. Dents, scratches and other kinds of mechanical damage to the surface are an indication of defective product. These defects are formed during the delivery of hot billets from the furnace. When the heavy plates (LZ steel casting) come down onto the roller tables, the billets catch against projections formed on the plates by the scale which covers the plate with a thick and, in some places, strongly adhering, layer. Damaged bars had to be ground and the plates had to be cleaned once a month with the grinder and replaced every three months. The cleaning and replacing of the plate was done at a complete shutdown on the furnace. All this took 3 to 4 days per month.

Now, the cast plates have been replaced with 10 mm thick and 0.8 m long plates of EI417 steel from the waste of plate – rolling production. The plates are laid directly onto the lining of the furnace floor and are fixed with brackets welded to the plates and fitted into appropriate seats in the brickwork (see figure). Their life is many times longer than that of the replaced plates; measurements showed that in ten months of 1957 they wore down 0.4 mm in thickness.



Fixing of plate to furnace floor: a – positioning of plate 1, and of facing 2. b – plate with brackets.

When necessary, the plates can be replaced without a shutdown of the furnace – through the delivery door for hot metal – in 5 to 10 min. This arrangement made possible a complete elimination of dent formation on the surface of rail-joint bars and a considerable reduction in the cost of furnace repairs.

MODERNIZATION OF SHEET MILL EQUIPMENT

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Novosibirsk Metallurgical Works

One of the most important methods of increasing output of existing industrial plants is mechanization and modernization. Side by side with large-scale improvement of industrial processes which entails large capital outlay, a considerable effect is attained by carrying out small-scale mechanization and modernization of existing equipment. Work of that kind was carried out in No. 4 cold rolling mill at our works.

1. Extension of pickling baths. For a long time the continuous pickling plant constituted a bottleneck for the mill. With the object of eliminating it, the pickling baths were extended by making use of the free space between them which was intended for the installation of the unit with the supporting roller and guides. In this way, the pickling surface in three baths of one continuous pickling line increased by 5 m in length. The speed of pickling increased by about 10%. The supporting roller unit was mounted above the extended part of the baths.

2. Increasing the speed of the machinery pulling the steel strip through the pickling and washing baths, and of the drive of the coiler. The speed of the strip on passing from the decoiler of hot-rolled coils to the loop pit before the acid baths can be brought to 120 m/min while the speed of the strip on its passage through the pickling and washing baths is only 60 m/min.

Some steel sheets may be passed through the pickling train and coiled with the roller-type coiler at a substantially higher speed than specified in the design. The speed of delivery of the sheet from the pickling train was increased by changing the gear ratio of the cylindrical worm reduction gears of the pulling rollers' drive before and after the baths, and of the worm reduction gear of the coiler. Owing to the doubling of the turns in the worm and the installation of worm couples with halved gear ratio, the speed of the sheet in the pickling train was brought to 100-120 m/min and hence the output could be increased.

3. Improvement in uncoilers in the pickling and other units of the plants. The operational units had to be frequently stopped as a result of breakdowns of the screw mechanism for lifting coils to the cone level. Because of the large amount of scale and metal particles getting between the screws, the screw couple was useless after 250-300hrs of operation, thus necessitating emergency repairs of decoilers and considerable consumption of spare parts. The screw lifting mechanisms were replaced by hydraulic (oil) lifts without extensive modification, according to the project by G.K. Ravilov. The arrangement consists of a hydraulic plunger cylinder (lifting jack) mounted on the frame of the decoiler in place of the screw jack and operated from the pump station.

The introduction of these lifts on the decoilers of the pickling units, on the flying shears of the drum type and on the decoiler of the 740 continuous sheet mill resulted in a considerable increase in output and a saving of more than 50,000 rubles.

The above described, and several other measures made it possible to increase the capacity to nearly twice the design capacity.

4. Modernization of the 740 continuous three-stand cold rolling mill. The speed of working rolls of the first and second stands was increased by means of changing the gear ratio of the toothed gear in the main reduction gear of the first stand from 1:11.3 to 1:9 and the gear ratio of the main reduction gear of the second stand from 1:9 to 1:6.3.

All work on changing of the gears was done during the scheduled overhauls of the equipment. As a result of this modernization the output of the mill increased by 4%.

5. Change of radial thrust bearings of the mechanism for gripping the end of the strip on the coiler of the 740 mill. The coilers broke down very frequently as they were not suitable for the type and degree of the stresses developed. After the replacement of two radial thrust bearings by a No. 316 radial ball bearing and a double collar roller thrust bearing, the emergency stoppages of the mill, due to breakdowns of the coiler bearings, ceased.

6. Modernization and mechanization of the equipment and operations on the finishing of sheets and strip. The technology of cold rolled sheet manufacture involves covering both sides of the sheet with a thin oil film. Two felt rollers, one of them driven by a motor, were used on this operation. Spindle oil was delivered from a tank through tubes onto the top roller. Tanks were manually filled with oil and covered sheets were also set manually into piles. The felt on the rollers wore down very quickly and the machines had to be stopped for a change of felt.

The group of innovators at the plant proposed that the felt rollers be replaced by cast iron rollers, manual piling of sheets mechanically-by means of an inclined gravity sheet piler – and that oil delivery and removal from the centralized oil system should be provided for. All this made it possible to discontinue the use of costly technical felt, eliminate labor-consuming operations on the overhaul and the change of felt rollers, eliminate manual sheet piling operation, which was unsafe for the operating personnel, and reduce oil consumption.

Annual savings after the introduction of oiling machines constituted 30,000 rubles.

BRICKLAYING OF CERAMIC RECUPERATORS

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"Krivorozhstal" Works, "Soiuzteplostroi"

Ceramic recuperators recently began to be installed at the holding furnaces for heating air up to 500-600°C. These recuperators are long-lasting, have a relatively large heating area and are simple to build.

Experience showed that the quality of the construction of recuperators depends to a large extent on the method of bricklaying.

Unfortunately, there is no one single system of work organization and bricklaying method for the ceramic recuperators. The quality of their construction is therefore lowered.

Most of the newly constructed furnaces are equipped with hot gas and air jet burners, designed by the Stalproekt, which do not require air blowing equipment. Therefore, air losses due to an inadequate gas-tightness of the ceramic recuperator can be somewhat reduced. Nevertheless, the pressure difference between the flue and air ducts of the recuperator reaches 25-30 mm of water, the air losses through leakages are fairly high and, therefore, a regular thermal operation of the furnace is disturbed.

The recuperator considered (Fig.1) consists of two or four sections separated by longitudinal walls built of chamotte brick.

Special shape refractory bricks (Fig. 2) have rectangular passages for vertical air flow. Combustion products pass horizontally through the channels formed between two neighboring shaped refractory bricks.

Because of the large number of joints between the shaped bricks, there is a leakage of air from the vertical air ducts to the flue ducts. Therefore, it is necessary to make the joints very tight.

The following factors are met with in the laying of the recuperator brickwork:

1) the variations in the geometrical dimensions of shaped bricks hamper a free passage of air through the air channels and increase the thickness of the joints;

2) bricklayers have to walk on the refractory brickwork of the recuperators, thus damaging the tightness of the joints;

3) the bricklaying takes a long time because of the necessity to allow time for an adequate setting of mortar before laying a subsequent layer.

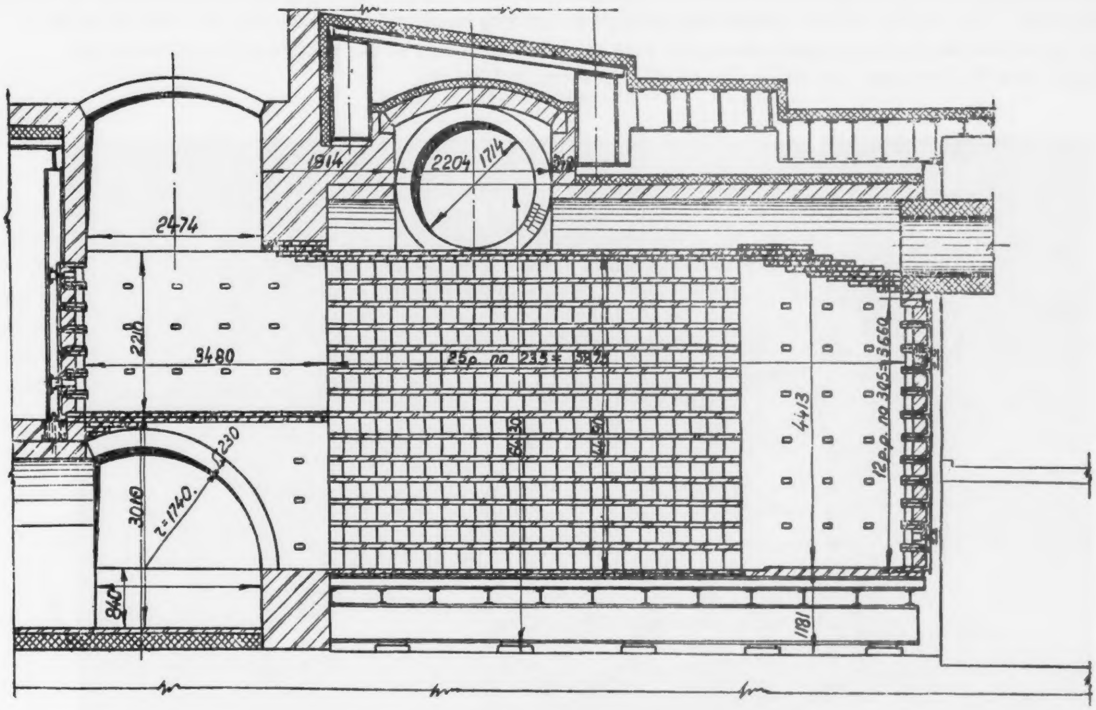


Fig. 1. Section through the ceramic recuperator.

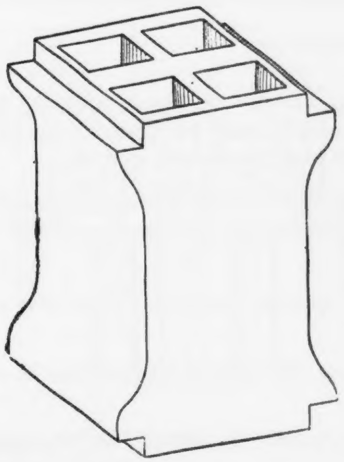


Fig. 2. Specially shaped brick for recuperator's brickwork.

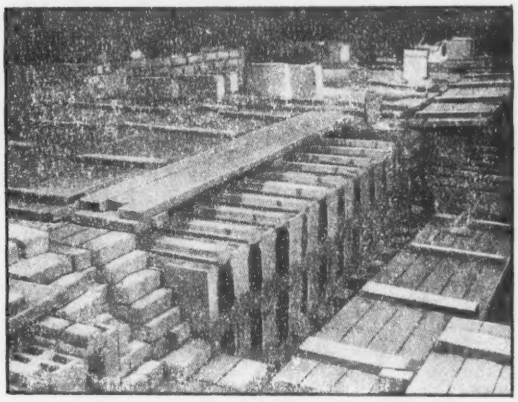


Fig. 3. Wooden platforms resting on the separating walls of the recuperator.

A new method of bricklaying is being adopted at present at the "Krivorozhstal" Works.

Prior to the laying of the horizontal row of the recuperator brickwork, the separating wallsbetween the sections are laid up to approximately one third of the height of the shaped refractory brick. Wooden platforms, 40 mm thick, are placed on these walls over the whole horizontal cross section of the recuperator (Fig. 3).

The laying of the bricks begins from the center and proceeds towards the periphery of the sections of the recuperator. This method allows a double number of workers to be employed on bricklaying, because the work can be carried out from two sides. During the work the bricklayers stay on the wooden platforms which are shifted onto the brickwork just laid as the bricklayers move on (Fig. 4).

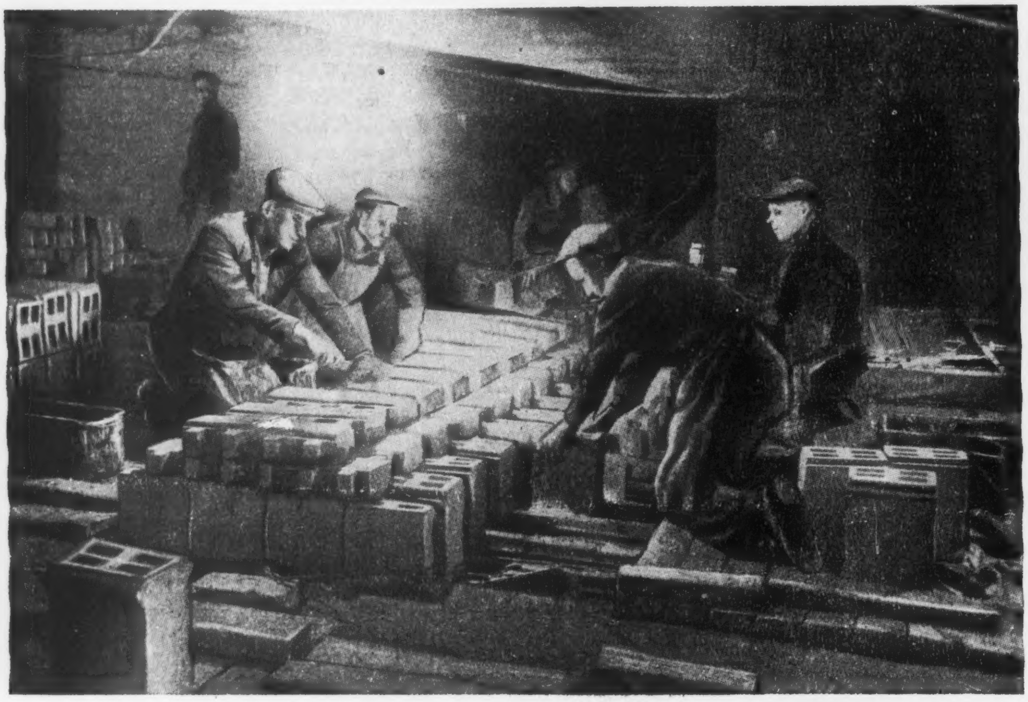


Fig. 4. New method of bricklaying for the recuperator.

The basic refractory bricks, including the front (polished) face of the brick, are laid on a bauxite mixture. The joints in the horizontal flue ducts of the checkers are covered with paste-thick bauxite solution and then the upper and lower surfaces of the channels are brushed over with a thinner bauxite solution.

When the laying of one horizontal row is finished, the separating walls between the recuperator sections are laid up to one third the height of the brick above the row just laid, the wooden platforms are placed in position and the laying of the next horizontal row begins.

Until wooden platforms are placed on the separating wall of the sections, workers and loads move on the separating walls.

Before the commencement of laying the subsequent horizontal row, the vertical channels must be cleaned of the solution.

Simultaneously with the recuperator brickwork, the flue checkers are laid on both side of the sections.

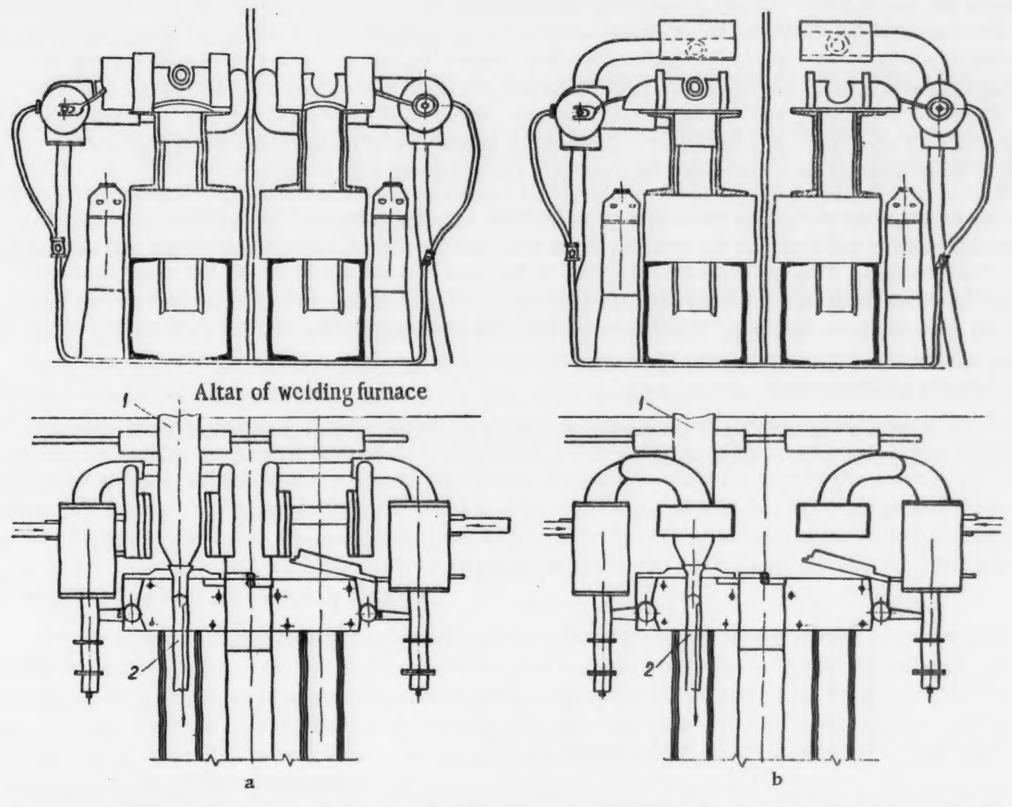
The new method of bricklaying eliminates mechanical damage to the brickwork by loads or workers. Differences in the dimensions of the shaped refractory brick are compensated for by adjustments of the thickness of the separating walls between the sections of the recuperator and the flue checkers. Thus, cutting the refractory brick for fitting can be avoided. It should be mentioned that cutting the refractory brick is not allowed as it very frequently causes cracks and impairs the gas tightness of the recuperator.

The adoption of the new method of laying of the ceramic brickwork of the recuperator made it possible to reduce the air leakage to 20%, reduce the time for bricklaying by 25 days and achieve a heating temperature of air of 600-650°C.

MODIFICATION OF THE METHOD OF BLASTING THE SKELP ON FURNACE-WELDING OF TUBES

Eng. T. I. Romershtein

The butt welding of pipes is carried out in one passage through the furnace. This is achieved by use of compressed air blast on the edges of the skelp. It is established that the blast of compressed air cleans the surface of the metal, heated to approximately 1300°C, from slag and scale. At the same time the temperature of the edges increases by a few tens of degrees. If the pipe welding is done without the air blast on the edges, not less than two passes have to be made. A good effect of blasting the edges is attained provided a uniform and sufficiently high (not below 4 atm) pressure of the blast on the edges of the skelp on all its length is maintained. For the prevention of a decrease in blast effect it is important to have the distance between the nozzles and the edge as small as possible.



Blasting of skelp on furnace welding: a – side blasting (old method); b – top blasting (new method); 1 – skelp; 2 – pipe.

At works where the method of furnace butt welding of pipes in welding bells is employed, the blasting of skelp edges with compressed air is done through slits of two box nozzles mounted on both sides of the moving skelp (see figure,a). This method, however, has several disadvantages:

1) When the skelp is drawn into the pipe, a twisting of the skelp from its usual flatwise into edgewise position is frequently observed; hence, the central part of the skelp, instead of its edges, is blasted; the

stiffness of this part of the skelp is lowered and the welding pressure is decreased.

2) Scale and slag, which on blasting fly off in the form of a shower or sparks, adhere to the nozzles; therefore the area of the air slits is reduced and sometimes they even become completely blocked; the adhering mass is impossible to remove completely even at a thorough maintenance of the blowing equipment; hence the effectiveness of the air blasting of the edges is seriously lowered and the quality of pipe welding is impaired.

3) On changing over from one diameter pipe to another it is necessary to change the box nozzles because the best effect of the blast is attained at a minimum distance between the air slits and the edges of the skelp. The change of nozzles entails stoppages of the mill, and, to avoid them, box nozzles of an excessive width are used in tube welding. This, however, has an adverse effect on the conditions of blasting because when wide box nozzles are employed, the distance between the air slits and the skelp edges is increased and, hence, the blast pressure is lowered and the quality of welding deteriorates.

All the above disadvantages are eliminated when top blasting, instead of side blasting, is employed (Fig. 1,b). Instead of two side box nozzles, only one, mounted above the hot skelp, is used. For space economy, the top-blast nozzle is fixed to the lower side of the water-cooled embrasure which covers the furnace door and protects the welder from radiation heat. The position of the automatic valve for letting the compressed air through the nozzles at the beginning of the skelp drawing and for switching off the air after the completion of the drawing, is retained as before. The shape of the tube, connecting the automatic valve with the nozzle, is changed a little in connection with the transfer of the box nozzle to a new (top) position. Single box nozzles are employed for blasting and, owing to their simplified design, are welded and not cast as previously. The box nozzle and the air slit are placed in such a position that the stream of compressed air impinges on the skelp edges in the welding zone just before the closing of the edges into a pipe shape.

In the new method of blasting in the process of drawing, the air stream pressure maintains the skelp in the horizontal position and therefore the twisting of the strip onto its edge disappears completely and the weld becomes much stronger. Slag and scale do not adhere to the blast slits and are blown off the edges downward and collect under the front end of the drawing and welding mill. Neither do slag and scale spray fall on the air blast slit situated above the skelp. There is no necessity for changing the box nozzles on switching to the production of pipe of a different diameter, as the nozzles are set in a fixed position at a minimum possible distance from the welding zone.

The new method of air blasting of skelp made possible a reduction in the consumption coefficient of metal down to 1.5-2.0 kg/t of finished pipes.

ORGANIZATION OF PRODUCTION QUALITY CONTROL

In the article by N. P. Inozemtsev, Ia. I. Sokol, I. F. Rysev, D. A. Tarasenkov and S. L. Zamiatin "Organization of Production Quality Control," published in the "Metallurgist" No. 9, 1957, the question of reducing the OTK (Department of Technical Control) staff and increasing the responsibilities of plant personnel with regard to the quality of production, was raised. Here are some comments on this article.

A. K. Bushuev, K. A. Tabunov and Iu. L. Levit

Department of Technical Control of the Nizhne-Tagil Metallurgical Combine

The article by the "Serp i Molot" workers elucidates correctly, in the main, the problem of the most effective and useful arrangement of the control personnel in the metallurgical plants. The OTK fullfils, in general, three tasks: supervision on maintaining of given technological conditions of the process and prevention of deviations from them, auxiliary production operations and the inspection of finished products. Accordingly, the whole control personnel can be divided into three categories.

To the first category belong the controllers of the furnace bays of open-hearth and rolling plants, controllers of rolling mills and so on. The existence of this category is not justified: if the technical production level is high, the operating personnel do not require prompting and can themselves ensure the observance of given technological conditions; if, on the other hand, there is lack of industrial discipline, the control personnel,of course, do not assist in consolidating the discipline but only help the violators of the technological conditions to avoid the responsibility. Or the management of the plant may reprimand an unconscientious worker or foreman.

Therefore, a maximum reduction of the controllers in the first category and the placing of the responsibility for the observance of technology on the operators should be aimed at.

The above considerations are correct in respect to the technological violations which can be discovered in the next operation within the plant or the works, and when the guilty will be found at once and the defective products rejected. There is in this category, however, a small group of controllers who ensure the quality of production locally and prevent the dispatch of rejected or low-quality products to the consumer. For instance, samples for all types of tests in the rail structural mill are taken at the hot-cut saws by the team of cutters. Taking into account the large number of sections and the wide range of tests, the sampling should not be entrusted without any control to workers whose duties also include the setting of saws, removal and loading of cuttings etc.; confusion and mistakes in the certification of the metal are thereby unavoidable. Therefore, the sampling should be supervised by the OTK.

To the second category belong the controllers on auxiliary operations where workers of low or medium qualifications are employed (filling in of heat certificates in open-hearth furnace plants, recording of various necessary indices, checking of schedules, recording of charging into the delivery from furnaces in rolling plants etc). As these operations, so far, are not mechanized and self-recording, but must be carried out, it is expedient to employ an OTK worker there — his certain independence from plant personnel will allow him a more objective recording of this or that data.

The third category consists of the controllers of finished production. As equipment and instruments which could replace a man on the inspection of the products are not yet available, this group of controllers must be retained. It is not expedient to include it in the plant personnel because the number of people would hardly change and the controllers should be independent of the plant personnel. From our point of view, the suggestion of the "Serp i Molot" workers to take the OTK from under the authority of the works manager is a mistake. This is an extreme. It is wrong to turn a controller into an inspector and to detach him completely from the team with which he works, as it complicates the relation to the plant personnel and may lead to hold-ups in production. The interests of the plant and of the section should be dear to the controller — as, for that matter, to all workers — and he should know about the progress in the fulfilment of the schedules and be aware that he is also participating in common successes and failures.

On the basis of the above, the OTK setup at our works was reorganized and as a result of the reorganization, it was possible to reduce the OTK staff by 17%, the workers being made available for other sections. In addition to the cutting down of some control points (mainly supervision), the OTK sections were combined and enlarged (7 were formed from 15), the working day of the controllers was planned more efficiently and some duties combined. The OTK sections of two open-hearth plants, the plate mill, the tire and wheelmill, the blooming mill and the rail structural mill were combined.

The personnel of the OTK section of the rail structural plant has a staff of over a hundred, employed mainly on the inspection of finished products.

In this plant, the control point at the 800 mill was abolished (the duties of the controller comprised the checking of rolled section and the supervision of the technology of the process) and the post of the controller of MPS inspection on taking and testing the impact test samples (the controller duplicated to a certain extent the work of the OTK at the saws) was eliminated. The duties of the first controller are successfully carried out by the foremen of the mill and the duties of the second were allotted to the controller at the saws whose duties include the internal control of product quality (sampling, mechanical testing, control of macrostructure impact test etc). The controller at the furnaces was retained, but whereas previously he was supervising the technology of the process (temperature of heating, time of exposure and so on) and a woman worker was supervising the flow of material, now this woman's work istransferred to another section and all her duties (distribution ofgradesand heats,alternation of lettered and unlettered blooms, and so on) are alloted to the OTK controller. Furnace foremen are responsible for the correct operation of the furnaces.

In the finished product stage, 11 people were employed on the recording of data for each load and on the basis of these data certificates were filled in. Those workers were controlled by six OTK employees who were completing the certificates and issuing them to the consumer. With the agreement of the management of the plant the system was changed; the posts of plant recorders were abolished, the OTK staff was increased by three men and the recording of production was fully entrusted to the controllers. Hence instead of 17 people, only 9 are now employed in this section.

Thus, some increase in OTK staff was fully justified; the total number of workers was reduced and the remaining ones were employed on the production processes.

In connection with the reorganization of the control system and the drawing, as far as possible, of the OTK personnel into the production processes, the question of the revision of the existing method of selecting the OTK personnel arises. At the present pace of work in the plants a controller should be healthy, capable of prolonged effort and well trained. Furthermore, he should have financial interest not only in the quality but also in the quantity of finished product. In industrial practice, however, there are dozens of examples where a controller executes work equal – in working conditions, efforts and responsibility – to that of a plant employee but gets less pay because he is paid by the time, irrespective of the output, and not according to the piece-rate system.

We consider that the transfer of the final-product controllers to the piece-rate wage system will:

1) provide personal interest in the increase of efficiency;
2) allow a gradual completion of the staff of the controller team with qualified and able workers;
3) bring to light substantial possibilities of a further staff reduction.

The problem of retirement age of OTK personnel engaged on final-product inspection should also be revised. At the age of 50-55, a man loses, to a certain extent, his sharpness of sight, his acuteness of hearing and his agility. The retirement age for controllers is fixed at 60 and for all other workers of the finishing and sorting section at 55. This position shoulddefinitelybe revised.

Head of the OTK, P. P. Breskin and Senior Engineer of the OOT, L. I. Urin

The Lenin Works in Dnepropetrovsk

The problem raised in the article by the workers of the "Serp i Molot" Works, of a revision of the duties of every OTK controller with the object of reducing the number of personnel employed on operational control, is undisputably very urgent.

After a thorough study of the OTK controllers' duties at our works in the open-hearth plant and the department of internal inspection and acceptance, the posts of casting bay controllers were abolished and the control duties on the preparation of the casting pit were allotted to the casting bay foreman. The posts of controllers on the inspection of molds and refractories were also abolished. Their duties were transferred to the controllers on the inspection of raw materials.

The OTK personnel is relieved of the duties of the inspection of auxiliary materials delivered to the main store and to the open works storages. The inspection is carried out by the personnel of the commercial section of the works. Scrap in the scrap shop is inspected by the foremen instead of by OTK workers. In this way, several separate sections of the OTK could be abolished in the open-hearth plant and on internal inspection. The combining of these sections made it possible to free one qualified engineer and five controllers for other duties.

The technical control section of the mechanical and casting plants are also eliminated. The men directly taking part in production (bench workers) were given personal marking stamps. The responsibility for the quality of castings and parts made for local orders is placed on the shift foremen. Only the parts made for outside orders are inspected by the controllers of the OTK.

In place of an OTK section in the consumer goods shop, a group for the inspection of finished articles and components was organized. The group is headed by the inspection foreman. Owing to these arrangements, it was possible to reduce the number of OTK sections from seven to four and to leave one control group.

A reorganization of the material flow in the mills and setting up of additional receivers for finished tubes in the electrowelded tube plant, made it possible to free twelve controllers from the section of primary grading and three from the rolling section. Their duties were taken over by the mill foremen. In the section of tube finishing in that plant, the lathe operators were given personal marking stamps and made responsible for the quality of the finish. Now there are only two controllers, instead of six, in each shift. Nevertheless, the amount of defective product in these sections decreased.

The combination of the duties of controllers on adjoining operations and a more efficient planning of the working day of controllers (on breaking of billets, rolling, "spark" testing and so on) made possible a reduction in the OTK posts in the tube and seamless tube plants.

In the course of the last year, more than 30% of the OTK staff were freed for other duties owing to a more efficient organization of technical control.

For the improvement of work organization, the mechanical laboratory was transferred from the OTK to the TsZL (Central Works Laboratory) and the measuring laboratory to the department of the chief mechanic of the works.

The improvement of methods and the mechanization of inspection operations play an important part in the process of reduction of personnel engaged on technical control. Thus, with the object of eliminating manual measurements of tube wall thickness, the Institute of Physics of the Academy of Sciences of the Latvian SSR is developing for our works on apparatus for measuring the wall thickness of tubes in continuous flow, using radioactive isotopes.

Important work is now being done at the works on the development of an equipment for the detection of weld defects in the electrowelding plant. The adoption of this equipment will considerably reduce the labor-consuming operations on hydraulic testing of tubes and will make more than 20 men available for other duties.

The system of remuneration of operational personnel, as suggested in the article by the employees of the "Serp i Molot" Works will, undoubtedly, be conducive to a bigger output of first grade product.

However, some proposals of the authors of the article are, from our point of view, unacceptable. We do not consider it advantageous to make the plants responsible for the grading of the products. At the Lenin Works the controllers cope not only with inspection and acceptance of tubes but also with putting them into appropriate receivers, in spite of the difficult conditions of inspection. In addition, the OTK personnel has time in the course of inspection to mark and stamp the tubes and write out appropriate labels. Hence, there is no need to overload the plant personnel with the classification of tubes, as such a duplication is quite superfluous and would lead to an increase in the number of workers.

The OTK should not be taken from under the authority of the works manager, as the overwhelming majority of leaders of industrial establishments take a responsible attitude to the problem of quality control and do not allow any violation of the regulations.

R. I. Razumovskaia and V. A. Chernous

Section Heads of the OTK at the "Zaporozhstal" Works

In our opinion, the post-operational inspection can and should be reduced but only where it is advantageous to do so.

In the rolling plants at metallurgical works where a mix-up of steel grades is possible, the control should definitely be retained. The following technological operations may be placed into this category: charging of the metal into and delivery from the heating furnaces, marking and stamping of the material after the rolling, charging and delivery from the pickling lines, marking it after the cutting and others.

The control should be retained where various grade steels are rolled in one line because a possible mix-up may have troublesome consequences at the consumer plants.

At the "Zaporozhstal" Works, the inspection at the guillotine shear in the cold rolling plant was abolished without any detrimental effect on the production.

In the finishing department there were cases when the cutters at the guillotine shear passed uncut sheets for packing but this was detected owing to the careful work of the inspectors.

In the cold rolling plant the responsible attitude of the plant personnel engaged on the strip uncoiling machine improved and now it is possible to dispense with the OTK services.

It was fairly easy to organize work without controllers on the finishing of stainless steel, although initially there were serious complaints about the mixing-up of steel grades.

The control at the heat-treating (hardening) furnace, in the section where only two steel grades are treated, was abolished. Due, however, to the complex process (quenching, pickling at least twice, etc) the absence of inspection caused a mix-up of steel grades.

Therefore, it was necessary to introduce the inspection of stainless steel with regard to intercrystalline corrosion.

The control on the normalizing furnace in the hot sheet rolling plant was reorganized. The maintenance of the technological conditions is supervised there by the plant personnel. The removal of the inspection from the operations on metal discharge from the furnace was not found to be justified; complaints of mix-up of steel grades were frequently received from consumers and from the adjoining cold rolling plant. The works incurred large losses and had to carry out an additional costly analysis of the alloy steels. Hence, it is seen that the removal of control on the discharge from the furnace was premature.

Scientific research institutes should work out a reliable method of preventing mixing-up of steel grades and develop more extensively the automation of the determination of product dimensions. A new, wider approach could then be made to the problem of control reduction.

OUTSTANDING METALLURGISTS

A. A. RZHESHOTARSKII

Alfons Aleksandrovich Rzheshotarskii, an outstanding Russian metallurgist and metallographer, was born in Radom on October 22, 1847. In 1867, after completing a classical school (gymnasium) he matriculated at the Faculty of Physics and Mathematics of Warsaw University. In his third year at the University he transferred to the Mechanical Department of the Petrograd Institute of Technology which was the largest school for mechanical engineers at that time.

During his studies in the Institute, A. A. Rzheshotarskii took a serious interest in metallurgy and chose it as his profession.

Vigorous development of industry brought about considerable changes in metallurgy. The Bessemer and the open-hearth processes for the manufacture of cast steel, which began to displace wrought iron from all fields of applications, were invented. However, the theory of cast steel manufacture contained many unsolved problems which hampered the development of new methods of steel production.

After graduating from the Institute in 1875, A. A. Rzheshotarskii joined the Putilov Works where he worked at first as an operator at the first Russian 5-t open-hearth furnace built by A. A. Iznoskov, and where, after six months, he was appointed superintendent of that furnace. He studied the process of steelmaking thoroughly and in 1876 published his first scientific paper on the open-hearth process.

In the same year he was offered employment at the Obukhov Steelcasting Works which was at that time the main supplier of cannon, axles, tires and other steel products.

Dmitrii Konstantinovich Chernov, an outstanding Russian scientist, was in charge of the Bessemer plant at the works and A. A. Rzeshotarskii was given the post of head assistant in the plant and very soon mastered the unfamiliar process. Soon he became head of the plant and in two years after joining the works Alfons Aleksandrovich published his second work "The Bessemer Process and How it is Operated". In 1878, he wrote an article on the brittleness of iron and steel at high temperature.

In 1880, Rzheshotarskii published another work "Survey of the Recent Methods of Studying Cast Steel". He began serious study of crystallization and thermal treatment of steel. His intense study of the scientific works by Russian and foreign metallurgists resulted in a new paper "Various Theories On the Hardening of Steel" (1881). Continuing and developing views of D. K. Chernov, Rzheshotarskii pronounced in his article many interesting ideas, first of which regarded the effect of the mass of a piece on the hardening ability of steel. His theory of steel hardening is very interesting. Its main aspects differ little from the modern views on hardening.

In 1891, two 30-t open-hearth furnaces were built at the Obukhov Works. Steel for the shafts in large ships was made in these furnaces. In 1892, the Works was asked to produce steel armor. The large capacity – for that time – of the furnaces made possible a speedy solution of this problem. The Obukhov armor was not

inferior to the best foreign steels. The composition and the method of thermal treatment of steel was established by A. A. Rzheshotarskii. He proposed an original method of armor quenching by spraying, which subsequently was widely used in Russia.

Alfons Alexsandrovich studied in detail the effect of individual elements, in particular nickel, on the properties of steel. He wrote "the additon of nickel to iron increases the limit of elasticity and the resistance to fracture without lowering its ductility". Making use of this property of nickel, Rzheshotarskii produced a so-called nickelsteel armor for which he was awarded a gold medal by the Navy authorities.

Rzheshotarskii was a pioneer in the field of metal microphotography. In 1898, he published "Microscopic Studies of Iron, Steel and Pig Iron". A. A. Baikov wrote in his review of the work: ". . . .in European literature there is no such complete and, moreover, directly applicable, study of this problem and in this respect it will always remain a masterpiece. . . ."

The crystallization process, various forms of segregation, methods of studying steel and the method of microsection preparation were described very clearly in Rzheshotarskii's book.

In the second part of the book the considerations of a possible relationship between iron and carbon in steel were given. Here, Rzheshotarskii used the theory of Chernov on the critical points. The author described the structural components of steel and gave them the names of zhelezit (ferrite), stalit (perlite) and zakalit (martensite), and discussed the structural changes of steel on heating and the effect of different parameters of thermal treatment on the properties of metal.

In this book, Rzheshotarskii showed convincingly the importance of microscopic analysis of metal for science and industry. The book "Microscopic Studies of Iron, Steel and Pig Iron" was highly valued by metallurgists. In 1898, the Russian Technical Society awarded the author a gold medal of the Society.

In 1899, A. A. Rzheshotarskii was appointed chief metallurgist of the Obukhov Works. He remained in this post till the end of his life. In the last years of his work he was engaged on studies of the basic and the acidic open-hearth processes, continually endeavoring to improve the quality of open-hearth steel.

In 1902, A. A. Rzheshotarskii acepted the invitation of the Petrograd Polytechnical Institute and became head of its Metallurgy Department, but he did not leave the job at the Obukhov Works. In 1903, Alfons Aleksandrovich fell ill, and on January 16, 1904 he died.

All the work of A. A. Rzheshotarskii – as a practical metallurgist and as a research scientist – constitutes an invaluable contribution to the world's treasury of metallurgical science.

L. Gagarin.

FROM THE HISTORY OF TECHNOLOGY

FROM WROUGHT IRON TO CAST STEEL

Wrought iron is a relatively soft metal. Even in early times the need for its machining compelled metallurgists to search for harder metals for cutting tools. Carbon steel was such a material. Its ability to be hardened and to undergo other forms of thermal treatment made possible its use for the manufacture of steel articles with the most diverse properties.

At present it is still difficult to determine, not so much the old methods of carbon steelmaking, as the time of their appearance. All that is known is that the damask steel – carbon steel which could be produced

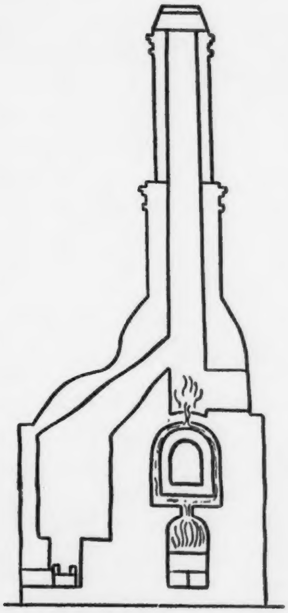
by the crucible method — was manufactured many centuries ago, in particular in the countries of the Middle and the Far East. Experts in India, Persia, and Syria were famous in the art of making weapons from damask steel. As the weapons made of that steel were extremely valuable, the method of making damask steel was kept in most strict secrecy.

The damask steel could be easily distinguished from any other steel by the intricate pattern on its surface. A damask saber gave an extremely clear ring on being struck, cut a silk scarf in the air and cut iron without a jagged edge. It could be bent without breaking and would come back to its original form. In due course the manufacture of damask steel ceased and the secret of its manufacture was lost.

In old Russia, steel production occupied an important position in the ferrous industry. Cutting tools, weapons and instruments were made of steel. The following methods were, most probably, employed for steel manufacture.

The ore smelting was carried out in a raw-blast furnace using excess charcoal by tapping slag frequently and slowing down the process by limited blast input. The bloom obtained was forged into plates which were then welded. Owing to repeated forging into layers and welding, the metal obtained was of a laminated structure.

It was possible to make steel from smelted iron. For this purpose, the bloom iron, covered with charcoal, was heated in a furnace or a forge. The surface of the metal became carburized and hardened after quenching in snow or water. The quenched top layer was broken off the bulk of the metal with hammers. The process was repeated until all the iron was converted into steel plates. When the plates were welded they constituted metal of lamellar structure or natural steel (uklad) as it was called in literature accounts beginning in the XVIth century.

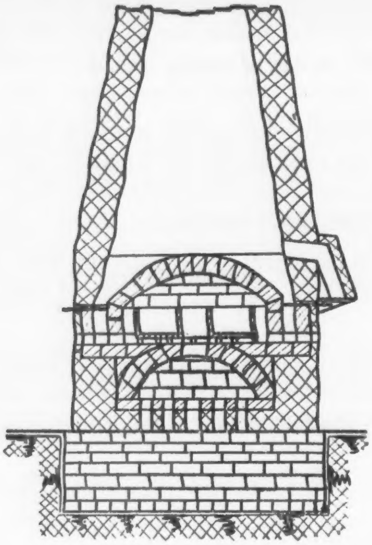


Furnace for cementation and steelmaking constructed by S. I. Badaev (1810).

Early Russian experts knew the art of metal carburizing. Finished articles, in the main, were subjected to carburizing. For this purpose they were either wrapped or covered with organic materials (hide, horn shavings, hoof shavings etc), coated with clay and heated in the forge. Later on, however, the carburization methods of iron articles were forgotten and carbon steel in the beginning of the Middle Ages was obtained only in the form of bloom steel or natural steel (uklad); at the end of the Middle Ages only natural steel was known.

The establishment of pig iron production and the development of the refining process brought about the development of a new method of carbon steel production, based on new principles of the metallurgical industry. Thus natural steel was obtained by conversion of pig iron and not from bloom iron. Ordinary pig iron was "converted" in a furnace, very similar to a bloomery, where pig iron was melted under the action of continuous air blast and was tapped directly onto the floor of the plant. Rapidly cooled metal (melt) together with scale and the remainder from the previous tapping was again charged into the furnace and heated to a higher temperature. Steel was obtained which was called natural steel or "uklad". To improve the properties of natural steel it was forged into plates, several of them were set into a pile, welded and again forged into a plate. The plates were folded, welded and forged again. The process was repeated several times (up to 12) depending on the required quality of steel.

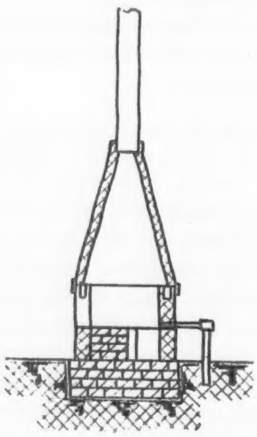
At the beginning of the XVIIth century some metallurgists attempted to reintroduce the carburization of soft iron. In 1613, two gunsmiths in Liege (Belgium) P. Hudron and D. van Bull, and quite independently in



Furnace for cementation at the Revdinsk Works.

1617, B. V. Elliot and M. Masay in London, proposed that pieces of iron should be heated with charcoal powder and other materials until the metal was saturated with carbon. In 1722, the French physicist, Reaumur developed the technique of carburized steel (blister steel) manufacture and the design of a carburizing furnace in detail. The carburization method was soon widely adopted in many countries. However, the properties of carburized steel did not satisfy the requirements of developing technology. Defects were frequently found in the articles made of carburized steel. The metal was not uniform, the surface layers having the highest carbon content. Blisters formed frequently on the surface and therefore some types of carburized steel were called blister steel. The starting material for carburized steel was bloom iron, itself non-uniform in composition, and therefore it was difficult to produce uniform steel.

The search for a new method of high-quality steel manufacture was continued. In 1722, Reamuir described some of his experiments on making casting steel in a crucible. In 1740, a Sheffield clock maker, B. Huntsman, when trying to make steel for clock springs, melted a piece of carburized steel in a crucible with charcoal and ground glass and obtained steel of a uniform composition. After prolonged experimentation it was found that by the addition of some material (pig iron, graphite, iron etc.)it is possible to impart different hardness to steel; thus, it was possible to use steel for the manufacture of all sorts of articles. Huntsman kept the results of his experiments secret for a long time. Soon, in a suburb of Sheffield, he built a foundry for the production of articles and tools from crucible steel.



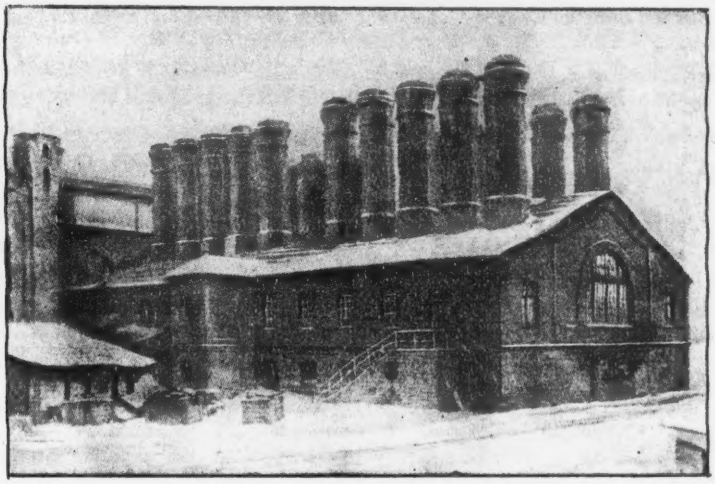
Crucible furnace for steelmaking at the Biserte Works.

In the beginning of XIXth century, the German firm Krupp bought the Huntsman patent and began the production of large castings. Metal was melted in several crucibles and then cast into one ingot. For a long time, metal in the ingot could not be obtained uniform because the starting material was puddling steel and it was difficult to achieve a uniform composition of this steel. Furthermore, the production of large steel ingot at that time involved considerable difficulties which metallurgists could not eliminate. Cast crucible steel was produced at Russian works by melting bloom and puddling carburized steel. Quite famous was the name of the serf Semen Ivanovich Badaev, who, at the Votkinsk Works, organized the production of crucible steel whose quaility was not inferior to foreign made steel.

The outstanding properties of cast steel, made in a single crucible, attracted the attention of many scientists and metallurgists. They tried to discover the lost secret of damask steel manufacture. Faraday, Bertier, Rinman and many others investigated the problem. But only the great Russian metallurgist, Pavel Petrovich Anosov succeeded in solving the problem.

The quality of the products of the Zlatoust Works, from steel made by P. P. Anosov's method, proved to be second to none. The fame of these products soon spread at home and abroad. Cast steel, which was

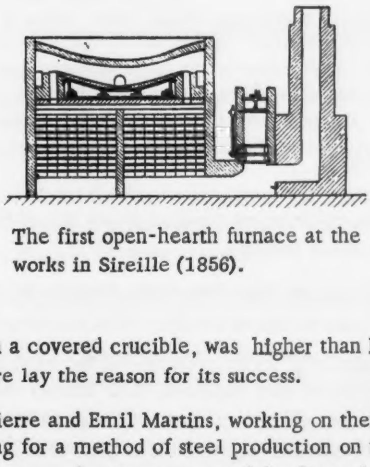
previously treated with some apprehension, began to draw more and more attention. The crucible process of steel manufacture was,however, very laborious and hence very costly.



View of the Obukhov Foundry.

Search for a more effective method of converting pig iron into steel was continued and metallurgists tried to obtain cast steel of uniform composition and in large quantities.

In the middle of the XIXth century several inventors in various countries worked on the problem of large scale steel manufacture. They approached the problem in different ways.



The first open-hearth furnace at the works in Sireille (1856).

In the Urals, the Russian metallurgist, Pavel Matveevich Obukhov, developed the crucible process of the manufacture of steel in large quantities. He charged pig iron, soft iron and ore into the crucible. Thus, it was possible to make steel of uniform composition in any number of crucibles. In 1857, P. M. Obukhov obtained a licence for his method and as early as 1857, the production of cannon from cast steel began in a factory in Zlatoust. Later on, this method was applied at the newly built Obukhov Steel Casting Plant in Petrograd and at Perm, Votkinsk and other works.

In England, Henry Bessemer carried out successful experiments on the manufacture of steel by blowing air through liquid pig iron. The quality of crucible steel, made in a covered crucible, was higher than Bessemer steel but the Bessemer process was less labor-consuming and there lay the reason for its success.

Pierre and Emil Martins, working on their plant at Sireille (France), spent many years of intensive efforts searching for a method of steel production on the hearth of a reverberatory furnace. But all their attempts failed because the temperature of the flame (puddling) furnace was too low. The invention of regenerators by the German engineer – F. Siemens – in 1856, made it possible to obtain the necessary temperature. Siemens used the principle of regenerations for air only and built a furnace for glass manufacture. P. and E. Martins achieved a successful melting of pig iron and scrap by applying the regeneration principle to air and gas. They developed the fundamentals of the technology of the scrap-process by correct proportioning of raw materials in the charge. In 1864, the Martins brothers took out the patent for their invention, built a furnace and manufactured cast steel.

Thus, in a very short time, three methods of producing steel of much better quality than wrought iron were developed simultaneously. Each of these three new methods, however, had its advantages and disadvantages which had a decisive effect on the industrial application of these methods.

In the crucible method of P. M. Obukhov, castings of over 300 puds could be obtained, the steel being of the highest quality. By the Bessemer method, about 30 puds of steel could be produced from pig iron in 20-30 min without additional expense on fuel and labor. In the open-hearth furnace, it was possible to produce about 150 puds of steel and at the same time to utilize scrap iron which accumulated in enormous quantities and which was of no other use.

This, combined with the simplicity of the process and a better quality of metal than the Bessemer steel, was a decisive factor in the development of the open-hearth industry.

Ferrous metallurgy entered a new period of development – the period of steel manufacture by conversion of pig iron.

V. B. Iakovlev.

NEW BOOKS

A.K. Solovkov, A.G. Trifonov and A.G. Elizarov. Bricklaying and Fettling of the Hearth of Open-hearth Furnaces. Sverdlovsk, Metallurgy Press, 1957. Price 4 r. 15 k.

The advance practices of the Magnitogorsk Metallurgical Combine on building and fettling new wholly-basic hearth of open-hearth furnaces are described in the book; processes of formation and erosion of the furnace fettling and experience on the maintenance of the hearth during furnace operation are discussed.

The book is a valuable manual for foremen and steel workers and can be useful also for technical personnel of metallurgical works.

L.G. Degtiarev. Economics of the Open-hearth Process. Moscow, Metallurgy Press, 1957. Price 2 r. 60 k.

The book contains an account of the basic problems of the economics of the open-hearth process: characteristics of the basic and working funds, and finished production; the problems of work planning, wages production cost and earning capacity of plants. Wholesale prices of raw materials and fuel for the open-hearth industry are quoted.

The book is a valuable manual for workers and foremen in the open-hearth furnace plants for extending their knowledge in the field of the economics of the open-hearth furnace industry.

E.I. Tishchenko and A.S. Emelianov. Dismantling and Bricklaying of Blast Furnaces. Sverdlovsk, Metallurgy Press, 1957, 335 pp. Price 9 r.

The book contains a description of the basic principle of organizing major overhauls of the blast furnaces and a detailed discussion of the method of dismantling and bricklaying of blast furnaces. The authors describe advanced practices on repair and discuss the equipment used on repairs. Considerable attention is paid to the mechanization of repair operations. The information on the technology of the blast-furnace process, refractory lining of the furnace, standards for refractory materials and safety rules during overhauls are given.

The book is a valuable manual for team leaders and bricklayers engaged on blast-furnace overhauls.

I.D. Vikhrev. Reconstruction of a large blast-furnace by means of lifting, Moscow, Metallurgy Press, 1957. 103 pp. Price 5 r.

The book contains a description of the reconstruction of a blast furnace at the Nizhne Tagil Metallurgical Combine by means of lifting. Several examples of furnace repairs by this method are given: the lifting of the furnace hearth at the Chusovsk Works, the moving of furnaces at the Frunze and the Krivoi Rog Works etc. Practices of American works on the transfer of furnaces are also given.

The author discusses basic problems in the organization of work in furnace repairs, describes the equipment for furnace transfer and gives the calculations necessary for design and planning and the technical and economical indices of furnace reconstruction by means of lifting.

The book can be useful for design engineers, constructers and fitters employed on construction and repair of blast furnaces.

METALLURGY ABROAD

STEEL ROLLING IN ENGLAND

A. V. Istomin

In England the majority of sections are rolled from large ingots. 2-8 ton ingots are used for rolling rails, beams, and steel sections, and 5-20 ton are used for plate rolling. Only a few old mills employ ingots of less than 2 ton weight for rolling thin sheet and billets.

There are few large rolling mills in England. In the largest of them, the plate-rolling mill at the Abbey Works of the Steel Company of Wales, about 2.2 million tons of slabs per year are rolled. There are three or four plants in England with an annual output of 1 million tons of ingots apiece. Large rolling plants specialize in one kind of rolled product.

There are many small steel works in England, their rolling mills being supplied with billets from the large works. Many of them are situated in the districts where the steel products are used, and they manufacture a very large variety of rolled product in small batches depending on the requirements of consumers.

Heating Facilities

In all works the ingots are heated in multichamber soaking pits. A large number of them were built after the Second World War, the pits being of various types; at some works two, three, and even four different types of soaking pits can be seen in one plant.

At two works there are pits with circular chambers built before the War. They are fired with cold gas of a high calorific value and are provided with waste-heat boilers. These pits are very efficient but have a low durability of chamber wall brickwork, where the small cross section of the chamber passes into the large one and on which the ingots rest during the heating.

At one of the works there are new regenerative-recuperative soaking pits, with elongated rectangular chambers (12 x 3 m) fired with gas, heated to 250°C in metal-constructed recuperators; air for combustion is heated in regenerators.

In the plant being constructed at the Lakenby Works for the manufacture of wide-flange beams the new soaking pits are of recuperative type with one-side top heating. The gas-air mixture for these pits will be heated in metal-constructed recuperators— the gas to 450°C and the air to 650°C.

New soaking pits at a recently modernized plant for the manufacture of high-quality rolled product also have one-side top heating. Producer gas of 1400/kcal cu m calorific value is employed as fuel.

Hot ingots constitute 75-95% of all ingots charged into the pits. At two works there are continuous tunnel furnaces, for preliminary heating, through which cars loaded with ingots move. After leaving the furnace the cars are unloaded and are sent on the return track to the charging end of the furnace.

The fuel consumption in the soaking pits varies within wide limits. At the Abbey Works, where about 95% of the ingots for plate rolling enter the pits hot, mean fuel consumption constitutes about 200,000 kcal per ton. At another works, where parts of the pits are of an older type without recuperators and only 80% of ingots for plate rolling are hot when charged into the pits, the fuel consumption constitutes about 375,000 kcal per ton.

Primary Bills

There are about 60 primary mills of various types in England, a considerable number of them being out-of-date and of limited productive capacity. At the end of the Second World War and after it a number of old primary mills were replaced by new ones and, in addition, several new mills were installed.

The largest preliminary mill is the blooming and slabbing mill at the Abbey Works, made in the USA. It is designed for rolling 20-ton ingots into slabs up to 1760 mm wide. The working rolls of this mill revolve in roller bearings and are driven by separate electric motors of 500 hp each; the counter-balance of the top roll is of counter-weight and lever type. At a distance of about 28 m from the horizontal rolls, vertical rolls are situated. At the end of 1956, the annual output of this mill was more than 2.2 million tons. With the object of raising the annual output of the plant to 3 million tons, it was decided to replace this mill by a universal slabbing mill, retaining the existing mill roll drives.

Most of the new primary mills are made by an English firm. One of them is the 1060 blomming and slabbing mill (with fluid friction bearings) intended for rolling 14-ton ingots into slabs of up to 1400 mm width. In the plant being constructed at present at the Lakenby Works of the Dorman Long Co. for the manufacture of wide-flange beams, it is planned to put a new 1320 blooming mill, driven by two electric motors of 4000 hp each, into operation, the mill being intended for rolling ingots of 4-20-ton weight. A particular feature of this mill is the separate drives for the first four rollers of the roller tables.

Working rolls made of cast steel are employed in all operating blooming and slabbing mills. In the slabbing and blooming mill of the Abbey Works two ingots are rolled simultaneously, the ingots passing close to each other between the working rolls.

At some blooming mills and at one blooming and slabbing mill there are hot scarfing machings, which are placed between the rolling stands and the shears and are used for the treatment of the semi-products which have surface defects. In particular the edges are treated on the slabs intended for sheet production. In spite of the loss of about 2% of metal on finishing, the introduction of machine scarfing is considered economical as it considerably reduces the time for the surface conditioning of semi-product and increases the output of good product in the further processing of the metal.

The surface conditioning during intermediate storage is done mainly by hand with gas cutters and partly with grinding discs. At the Samuel Fox Works the 2.5-ton ingots of stainless steel are scarfed with gas cutters; a special powder, delivered to the burner under pressure, is used for this purpose. A fully mechanized stand for finishing billets by grinding is also in this Works.

Billet Mills

Billets for section mills and wire rod mills are rolled at continuous billet mills and partly at other types of mills.

After the war, English firms made two new continuous billet mills together with a blooming mill necessary for providing material for continuous billet mills. One mill has six stands with horizontal rolls 530/480 mm with common drive and two stands with vertical rolls; it is intended for rolling square billets 50 – 100 mm and sheet

billets of up to 450 mm width. The working rolls are mounted on frictional bearings: the billets are cut with electric flying shears.

The second mill, installed together with a new 1100 mm blooming mill at the Consett Iron Company, has stands with horizontal and vertical rolls placed alternately, the billets being rolled without turning. The stands are arranged in two groups; in the first group there are three stands with horizontal rolls of 812 mm and three stands with vertical rolls of 760 mm (each stand driven by an electric motor of 1000 hp); in the second group there are two stands with horizontal rolls of 610 mm and two with vertical ones of 560 mm, each stand driven by an electric motor of 1250 hp. The mill is designed for rolling square billets 90 mm and slabs up to 610 mm wide and 67 mm or more thick in the first group, and square billet 45 mm and slabs 101×38 to 203×55 mm in the second group.

Rail and Beam Manufacture

Development of the production of rails and large standard beams in England took place mainly through the modernization of some old mills. Thus after the modernization of the mill at the works of the Cargo Fleet Co., the production of wide beams with flanges of up to 300 mm wide was started.

At the Lakenby Works of the Dorman Long Co. – big manufacturers of structure steel product – a plant for the production of wide beams is being put into operation. The universal mill installed in that plant, for rolling beams with flanges up to 415 mm wide, and with a height of up to 914 mm was made in the USA and is similar to the well-known mill, used for the purpose, at the Lackawanna Works (USA). Part of the auxiliary equipment of this mill was made by English firms.

Because the structural mill is not fully loaded and is frequently stopped for roll changing, new equipment, consisting of a two-high reversible stand 1010 and a four-stand continuous billet mill 530 for rolling billets for sections, is being set up behind the 1320 blooming mill and along the structural mill. It is planned to produce 450,000 tons of beams and 200,000 tons of square billet of 50-100 mm annually for a continuous small section and wire mill which is to be installed at that works.

In the operating plant of the Cliveland Works a new large section 580 mill was set up which comprises a primary three-high stand placed apart and three finishing three-high stands placed in one line. In the number of stands and their arrangement the 580 mill is similar to the 650 mill of our "Azovstal" Works. Two old structural mills in that plant are to be dismantled when the 580 mill is put into operation.

(To be continued in the next issue)

SIGNIFICANCE OF ABBREVIATIONS MOST FREQUENTLY ENCOUNTERED IN SOVIET PERIODICALS

FIAN	Phys. Inst. Acad. Sci. USSR.
GDI	Water Power Inst.
GITI	State Sci.-Tech. Press
GITTL	State Tech. and Theor. Lit. Press
GONTI	State United Sci.-Tech. Press
Gosenergoizdat	State Power Press
Goskhimizdat	State Chem. Press
GOST	All-Union State Standard
GTTI	State Tech. and Theor. Lit. Press
IL	Foreign Lit. Press
ISN (Izd. Sov. Nauk)	Soviet Science Press
Izd. AN SSSR	Acad. Sci. USSR Press
Izd. MGU	Moscow State Univ. Press
LEIIZhT	Leningrad Power Inst. of Railroad Engineering
LET	Leningrad Elec. Engr. School
LETI	Leningrad Electrotechnical Inst.
LETIIZhT	Leningrad Electrical Engineering Research Inst. of Railroad Engr.
Mashgiz	State Sci.-Tech. Press for Machine Construction Lit.
MEP	Ministry of Electrical Industry
MES	Ministry of Electrical Power Plants
MESEP	Ministry of Electrical Power Plants and the Electrical Industry
MGU	Moscow State Univ.
MKhTI	Moscow Inst. Chem. Tech.
MOPI	Moscow Regional Pedagogical Inst.
MSP	Ministry of Industrial Construction
NII ZVUKSZAPIOI	Scientific Research Inst. of Sound Recording
NIKFI	Sci. Inst. of Modern Motion Picture Photography
ONTI	United Sci.-Tech. Press
OTI	Division of Technical Information
OTN	Div. Tech. Sci.
Stroiizdat	Construction Press
TOE	Association of Power Engineers
TsKTI	Central Research Inst. for Boilers and Turbines
TsNIEL	Central Scientific Research Elec. Engr. Lab.
TsNIEL-MES	Central Scientific Research Elec. Engr. Lab.—Ministry of Electric Power Plants
TsVTI	Central Office of Economic Information
UF	Ural Branch
VIESKh	All-Union Inst. of Rural Elec. Power Stations
VNIIM	All-Union Scientific Research Inst. of Meteorology
VNIIZhDT	All-Union Scientific Research Inst. of Railroad Engineering
VTI	All-Union Thermotech. Inst.
VZEI	All-Union Power Correspondence Inst.

Note: Abbreviations not on this list and not explained in the translation have been transliterated, no further information about their significance being available to us. — Publisher.

METALLURGIST IN ENGLISH TRANSLATION

March, 1958

TABLE OF CONTENTS

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Collection of articles. The blast-furnace industry. For scientific and technical personnel and university students. 1957. 4 r. 40 k.

Collection of works on the theory of the blast-furnace process. Edited by Academician M. A. Pavlov. For scientific and technical workers of research institutes and university students. 1957. 11 r. 55 k.

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Central Institute of Information of the Ferrous Industry. The ferrous industry of capitalist countries. Part V. New grade steel and testing methods. For technical personnel and university and technical school students. 1957. 9 r. 95 k.

Iakobson, A. P., Operational experience on the Magnitogorsk sinter plants. For technical personnel, qualified workers and university and technical school students. 1957. 2 r. 25 k.

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Bannov, S.E., Repairs of electrical equipment of metallurgical works. For foremen and qualified workers, and technical school students. 1957. 11 r. 90 k.*

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Vernigor, P.I., Rappoport, I.S., The operator of electrical gas cleaning. Practical handbook for the training and further education of operators and foremen, team leaders, and repair personnel in the gas services of metallurgical plants. 1957. 4 r. 70 k.

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Collection of articles. The effect of nuclear radiation on the structure and properties of metals

(continued on opposite page)

*r = rubles, k = kopeks.